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INTERMOUNTAIN FOREST & RANGE EXPERIMENT STATION
FOREST SERVICE
U. S. DEPARTMENT OF AGRICULTURE
OGDEN, UTAH

Annual Report

1963

INTERMOUNTAIN FOREST AND RANGE
EXPERIMENT STATION

Joseph F. Pechanec, Director
Ogden, Utah

U.S. Department of Agriculture
Forest Service

THEN AND NOW

Like the hard-working husband in his later years, prone to let family anniversaries slip by, the Intermountain Station almost let a major milestone--its Golden Anniversary--pass unnoticed. Even though this notice comes nearly 2 years late, it is worthwhile to pause to recount a bit of history and to point to some changes that have taken place since our rather humble beginnings, before presenting the progress made in this, the 52d year of the Intermountain Station.

In 1911, Raphael Zon, R. Y. Stuart, and F. I. Rockwell, young and enthusiastic scientists, began the establishment of the Priest River Forest Experiment Station in northern Idaho. A year later, Dr. A. W. Sampson, one of the pioneers in the science of range management as we know it today, and two other scientists, Forman T. McLean and S. E. Bower, headed up Ephraim Canyon with horses and wagons to establish the Utah Experiment Station, later called the Great Basin Station.

The Priest River Forest Experiment Station was the predecessor of the Northern Rocky Mountain Forest and Range Experiment Station at Missoula, Montana; and the Utah Experiment Station similarly was forerunner of the Intermountain Forest and Range Experiment Station, Ogden, Utah. These were combined in 1954 into the present Intermountain Station.

Initial programs at Priest River were aimed at management of white pine timber and reforestation of the big burns. Those at the Utah Experiment Station were studies of grazing (chiefly as related to streamflow, erosion, and aspen reproduction) and silviculture of aspen.

Many of the objectives of 50 years ago remain as part of today's research. Present programs pursue several additional directions as a result of knowledge gained over the years, and as the needs of our population have presented new problems or demands in the use of forest and range lands. Major additions during these 50 years are: Inclusion of the silviculture of ponderosa pine, western larch, Engelmann spruce, and lodgepole pine, of mensuration, and of tree improvement as major components in our timber management research; inclusion of northern mountain grassland, sagebrush-grass, desert shrub, cheatgrass, and other types in our range management research; considerable expansion of the original limited program of watershed management research; and addition of research on fire control, on protection against insects and disease, forest economics and survey, forest utilization, and wildlife habitat. The most recent additions are forest engineering, forest recreation, and multiple use economics research.

By present standards, the beginnings of Intermountain Station were extremely humble, but they were tremendously productive. The early-day scientists were zealous and well trained. Knowledge developed by them and their successors has played a vital part in steadily improving levels of management of our private and public forest and range lands. Much of the technical knowledge we now use rather routinely is the product of research and administrative experience gained in the early and the intervening years. It may have become so routine that we think it was always known.

Our hats are off to our predecessors--those early scientists who, with inquiring minds, began to search for the secrets of the vegetation and the land of our forests and ranges. What they and their followers learned has greatly improved the use and increased the enjoyment of these lands by man. They did their job well!

Joseph F. Pechanec

Director

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(This report covers activities of Calendar Year 1963 unless otherwise noted.)

Significant advances in new and valuable information and in development, testing, and use of new equipment were achieved by our fire research projects this year. The more important of these are reported below.

FIRE CONTROL SYSTEMS

Project Lightning Track

Very low frequency direction finders (fig. 1) can locate lightning zones and record their azimuth. Two developmental models were designed, assembled, and operated by the Electronics Research Laboratory of Montana State College in cooperation with the Northern Forest Fire Laboratory. Located at Missoula and Bozeman, about 170 airline miles apart, these direction finders monitored an area between and south of the two cities. Verification data were collected by means of the U.S. Weather Bureau's Point 6 radar, the Project Skyfire-National Forest Administration lookout reports, and Weather Bureau teletype reports. These data are being scrutinized to determine the success and accuracy of lightning strike and storm locations by triangulation from these two units.

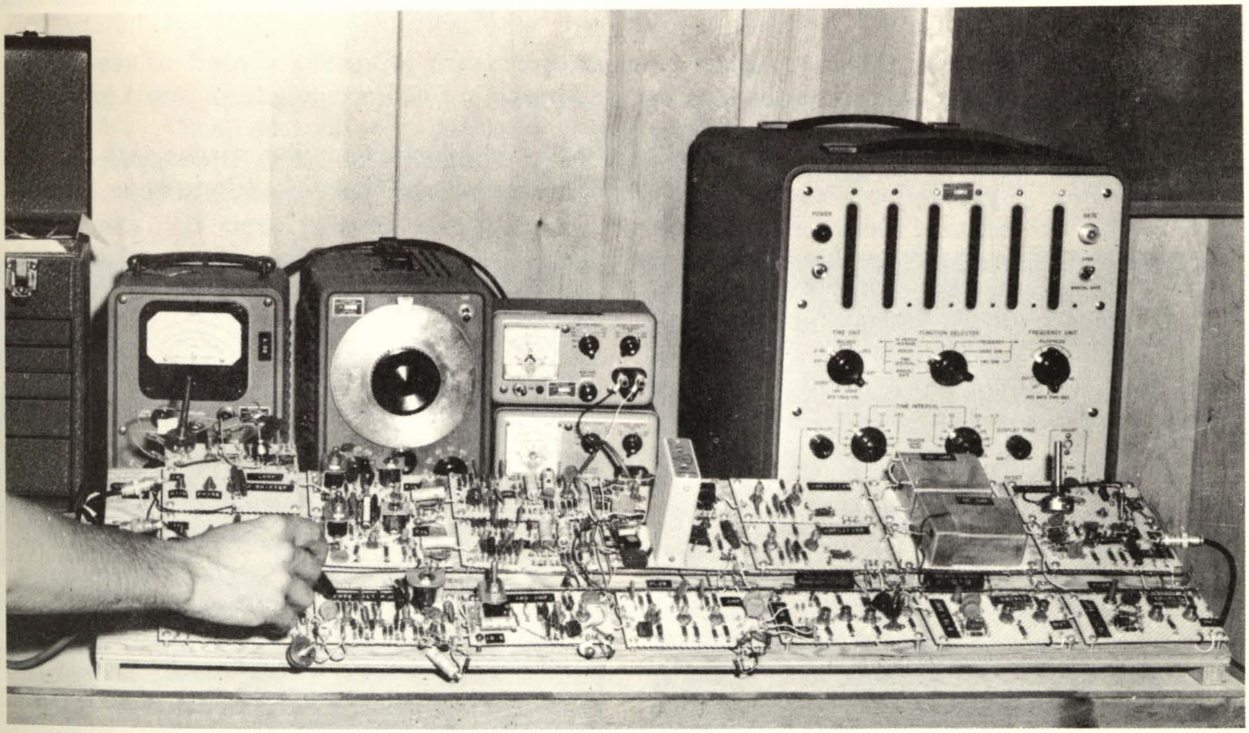


Figure 1.--"Breadboarded" developmental model of lightning-oriented direction finders.

Project Fire Scan

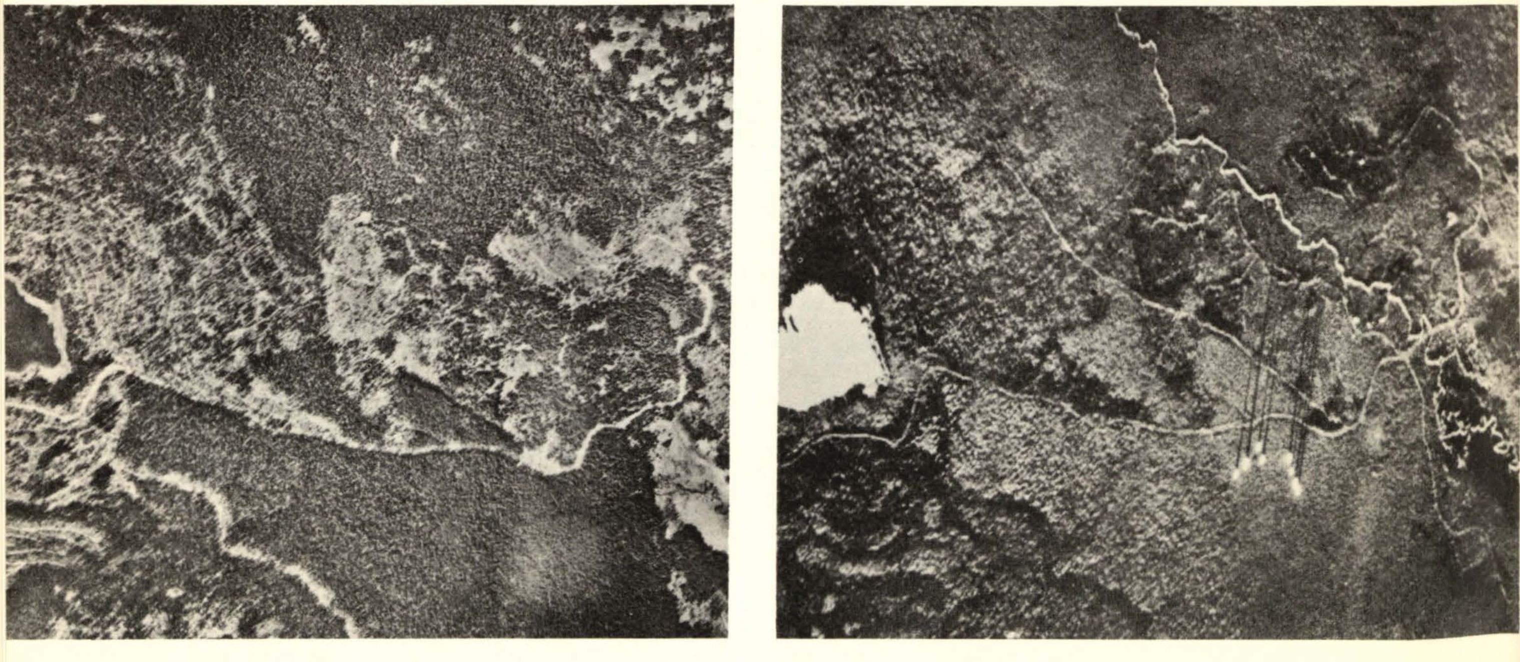
An important objective of Project Fire Scan is to determine the suitability of infrared-sensitive devices for detecting incipient forest fires from an aircraft when the fire lies within a range of 5 miles at either side of the aircraft. In order to provide this capability, the infrared system must be able to detect small fires under dense timber canopies at angles as great as 60° from the vertical. Tests conducted during the 1963 field season showed detection probabilities greater than 80 percent on simulated incipient fire targets at vertical angles up to 50° in lodgepole pine, ponderosa pine, and Douglas-fir--larch types. Tests in dense Engelmann spruce stands showed a detection probability of 60 percent at a 50° vertical angle.

Figure 2 compares an aerial photograph of the Engelmann spruce test area with an infrared image of the same area containing eight simulated fire targets.

In the past fire season we mapped several wildfires and immediately dropped the imagery obtained to the fire camp; subsequently, information from this imagery was transferred onto suitable base maps for use by the fire boss in planning suppression activities. A fire staff officer has been assigned to the Northern Forest Fire Laboratory to expedite application of this fire-mapping technique.

Figure 3 (right) shows a typical infrared image of a wildfire and an aerial photo of the same area (left) taken prior to the fire. A cooperative test was run with the Army Electronics Command over selected prescribed fires in the Northern Region; these flights (in a Mohawk OA1 aircraft) tested effectiveness of military infrared scanners and their associated telemetry and ground recording units. Mapping of prescribed fires has been sufficiently successful to justify additional tests on wildfires.

Figure 2.--Comparison of aerial photograph (left) of a stand of Engelmann spruce with an infrared image of the same area (right) containing eight simulated fire targets.



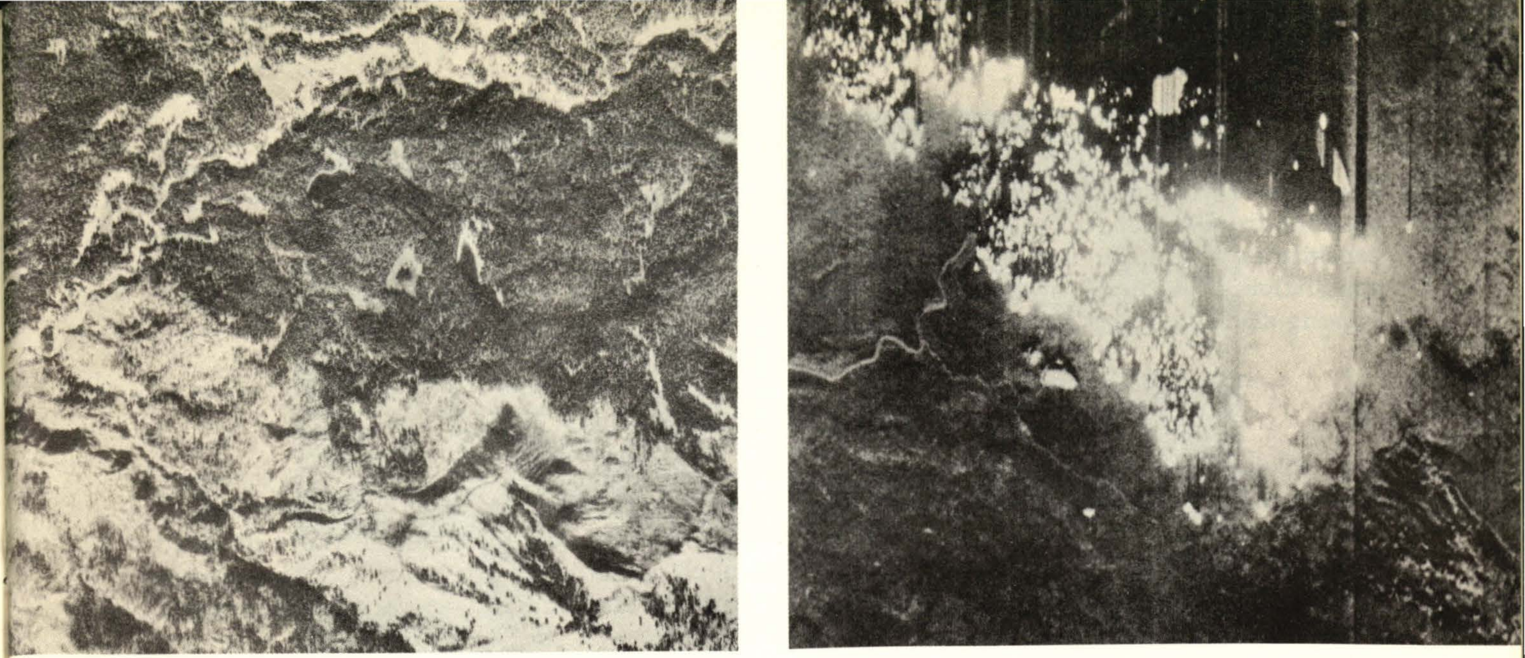


Figure 3.--Mapping the Gravel Creek fire, 1963. Left photo was taken prior to fire; right is infrared image of wildfire.

Prescribed Fire Studies

Results of several studies made necessary by the increased use of fire in forest management highlight progress this year in research on use of prescribed fire. Attention has been centered on the problem of broadcast burning for the combined purposes of hazard reduction and site preparation.

Results from a survey of prescribed burning practices indicated that wildfire hazards resulting from logging operations are adequately reduced by any broadcast burn that consumes fine fuels. Thus, the critical problem is burning well enough to provide an acceptable seedbed, planting site, or wildlife habitat. Data collected from 265 prescribed fires during the seasons of 1960 through 1962 showed that containment of these fires is largely a problem of burn layout. If cutting blocks had conformed to natural topographic boundaries, all but one of the 84 burns where difficulty in control was reported would have been more safely executed. The degree of site preparation achieved by a fire is a function of how hot it burns. Calorimetric analogs made from blackened 1-gallon cans were developed to assess objectively a fire's capability for site preparation. Losses of water from such cans placed in different fires helped to identify the weather and fuel conditions that favor objectives of prescribed burns.

Three cooperative studies of prescribed burning were carried on this year with nearby universities. One study, comparing the effects of spring burning with fall burning, was started at Montana State University's Lubrecht Experimental Forest (see fig. 4). First-year data on 40-ton per acre loadings of slash fuel show a marked contrast between averages of 1-inch residual duff layer in spring fires, and less than one-fourth inch in autumn-burned blocks. In another cooperative study with Montana State University, the relative rates of spread of heading and backing fires in artificial fuels were observed under controlled conditions in the Forest Fire Laboratory's wind tunnel. These tests, using wood flour and potassium nitrate models, are preliminary to large-scale studies of ignition timing for prescribed fires. At windspeeds of 5 to 10 m.p.h., heading rates varied as the 1.1 power of windspeed, and backing rates as 0.4 power.

Possibilities for remote ignition of large areas of logging slash are also being screened. The present practice of igniting slash with hand torches can be dangerous in heavy fuels. Conclusions from a cooperative study with the University of Idaho show that present energy output capabilities of LASER devices are inadequate for this work, but they hold promise for other application. Meanwhile we are continuing study of possible use of ballistic devices for igniting slash.

PROJECT SKYFIRE

Project Skyfire continued studies of weather modification and characteristics of thunderstorms and lightning discharges. This year the Project chiefly emphasized the development and field testing of new instruments, equipment, and measurement techniques. These included fast-response lightning sensors, a new "twin burner" cloud-seeding generator, and a precise method for determining distance to individual lightning discharges by recording the transit time of thunder.

Thunderstorm Characteristics

A significant project this year was analysis of data from records of 3,335 thunderstorms during the 9-year period of 1955 through 1963. These records showed that nearly one-half of all these storms produced 10 or fewer discharges to ground within 20 miles of the lookout. An additional 12 percent of these storms produced 11 to 20 discharges.

The regionwide network of special lightning and storm reporting lookouts begun in 1955 was reorganized and expanded in June. Forty-four lookouts now provide information on thunderstorm characteristics in Montana, northeastern Washington, eastern Oregon, northern Idaho, and northwestern Wyoming. This is eight more lookouts than we had in 1962 and doubles the number when Project Skyfire started 9 years ago.

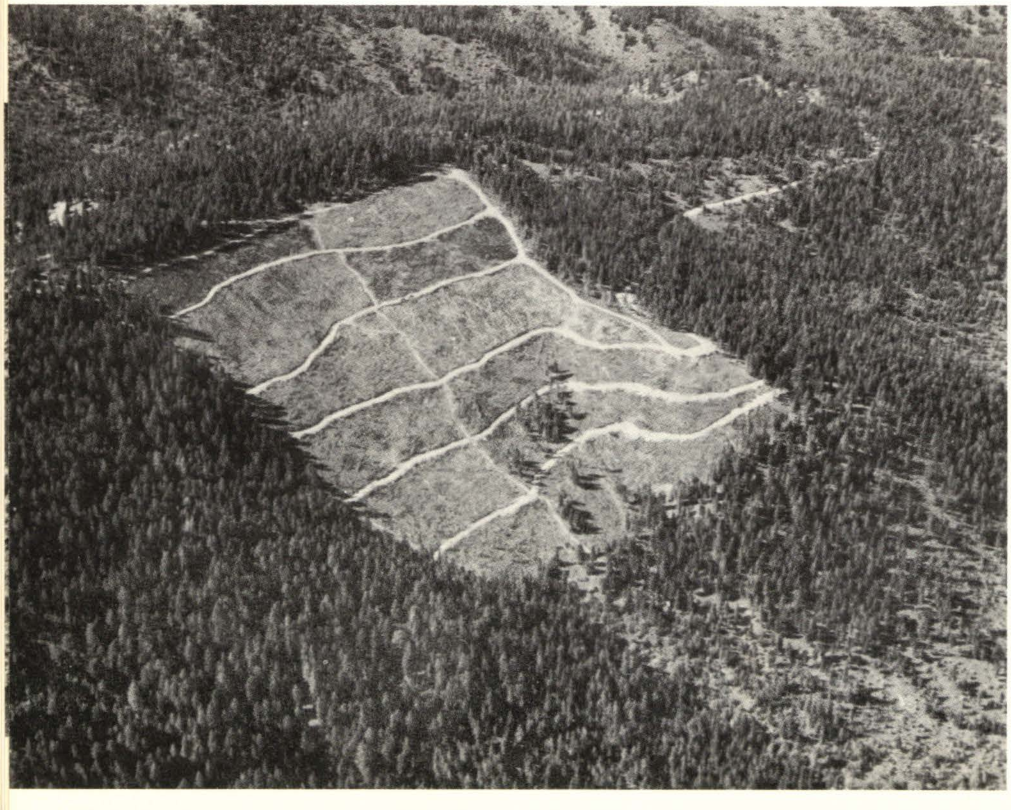


Figure 4.--The 40-acre prescribed fire slash study area on Montana State University's Lubrecht Experimental Forest. Randomly selected blocks are being burned in spring and autumn of 1963 and 1964.

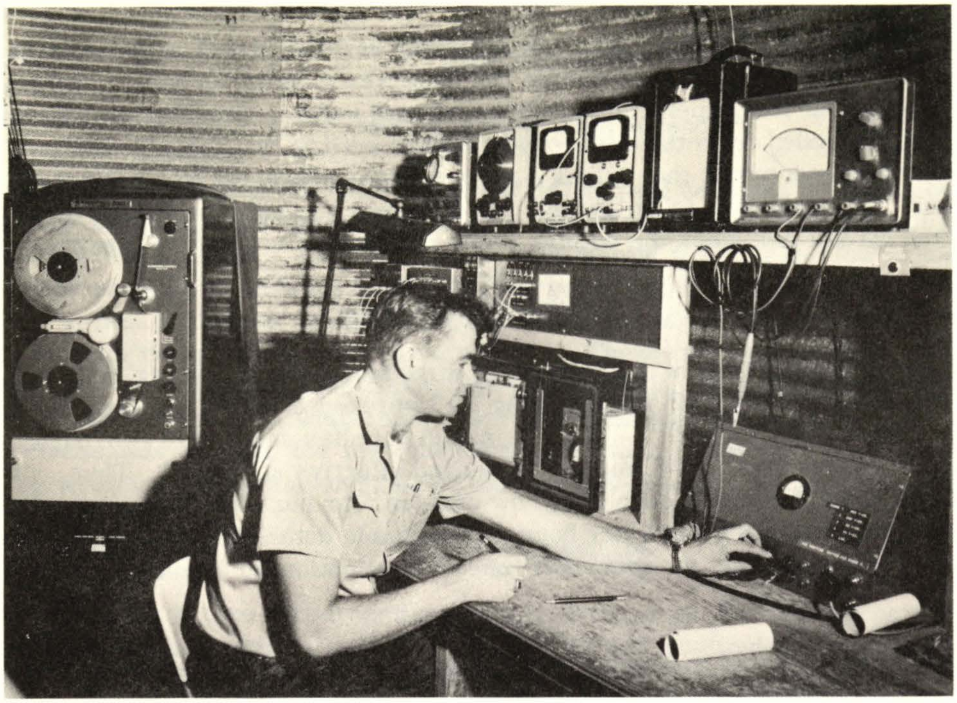


Figure 5.--Technician adjusts lightning discharge sensors in recording station near Philipsburg, Montana.

We used a portable data card-punching device for the first time to record observations of cloud dimension and precipitation at Black Pine Lightning Research Area near Philipsburg, Montana. These data supplement thunderstorm information provided by radar and full-sky cameras.

Locating Lightning Discharges

Instrumental techniques.--Three newly developed fast-response lightning sensors, called "electric field-change meters," were tested at Philipsburg in August (fig. 5). These meters detect the strength, duration, and polarity of many individual components of a lightning discharge--the complex phenomenon that the human eye sees only as a single flash. Our fastest meter detects separate events that occur in sequence within 1/1,000 of a second of each other in a lightning discharge. Signals from these meters are recorded on a seven-channel magnetic tape recorder and can be played back slowly on an oscillograph. This has the effect of slowing and lengthening the sequence of events and enables us to study the components of each discharge.

When the distance between a discharge and our field-change meters is known, we can calculate the amount of charge lowered to earth in a cloud-to-ground discharge. One method being tested at Philipsburg uses the sound of thunder to determine this distance. Three remote "satellite" microphones relay the sound of thunder to a tape recorder. Knowing the speed of sound, the time of discharge, the time of thunder arrival at each microphone, and the geographic location of each microphone, we can plot the exact location of the discharge.

Visual techniques.--We have also been testing several visual techniques for locating discharges. All these systems depend upon the observer's ability to see a discharge, sight accurately through an instrument, and read an azimuth value. One test device uses a pistol-shaped sighter suspended from the observation shelter ceiling by a flexible shaft. This shaft is connected to a Selsyn motor that drives a second motor connected to a pointer on an azimuth circle. When the observer is on target, he squeezes the trigger switch on his pistol; this breaks the circuit and stops the pointer at the correct azimuth of the discharge.

Weather Modification

Cloud-seeding experiments this year were aimed entirely at testing new equipment and methods. We made 10 aircraft flights using an improved model of the airborne silver iodide generator developed here in 1959.[1] The new model supplies solution to two burners (fig. 6), each of which produces about 10^{14} nuclei per second effective at -20° C. Thus, a Cessna-180 equipped with a generator under each wing now carries four burners. Consumption rate for each generator is about 6.5 gallons per hour. A portable data card-punching device used on these flights recorded time of generator use, consumption of solution, and generator malfunctions.

The classical theory of homogeneous nucleation indicates an expected production rate of about 10^{20} nuclei per second at 4-percent solution. Data from ground-based generators show a production rate of only about 10^{12} nuclei per second effective at -20° C. We are investigating possible causes of this apparent deficit in production.

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[1] See Intermountain Station Annual Report, 1959, p. 31.

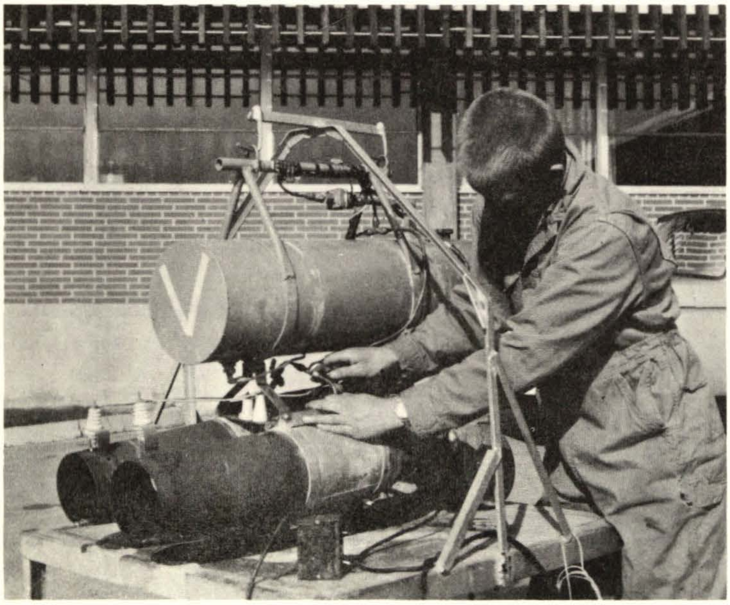

Figure 6.--This twin-burner silver iodide generator, mounted on a Cessna-180, doubles production of nuclei possible on earlier model.

FIRE PHYSICS

Mechanisms of Fire Spread

This year's studies of the mechanisms of fire spread centered on influence of wind velocity upon rate of spread and comparison of fire characteristics in fuel beds of ponderosa and western white pine needles. Results of more than 60 test fires in the low-velocity wind tunnel with fuel beds containing moisture from 4 to 12 percent and winds from 1.5 to 5 m.p.h. showed that rate of spread increases nonlinearly with increasing wind. Rates of fire spread in these two fuels diverge rapidly as windspeed increases. These two fuels showed great differences in burning rate, irradiance, flame depth, and flame length. At a windspeed of 5 m.p.h., fire spread much more rapidly in white pine than in ponderosa pine needles, but the rate of total energy release was greater for the ponderosa pine fuel. The test fires showed an inverse relation between rate of spread and rate of total energy release by the two fuels.

Fire Aerodynamics

Initial studies in fire aerodynamics came to fruition in the data gathered for the Mechanisms of Fire Spread program reported above. We are continuing the development of wind tunnel research facilities and measurement techniques. These techniques have been applied in measurement of free-stream turbulence and the fuel bed boundary layer turbulence. We now have evidence of the influence of boundary layer turbulence upon fire characteristics, and are continuing work in this study.

FIRE BEHAVIOR

Fuel Studies

Studies of fuel chemistry were expanded this year to include the analysis of products of pyrolysis. These products were segregated into char, tar, aqueous, and gaseous fractions. The gases identified by infrared analysis were carbon monoxide, carbon dioxide, and methane. The tar and aqueous fractions were run through a gas chromatograph (fig. 7, left) to identify their constituents, but analysis is not complete.

Percentages of ether extractables were determined for the needles of several coniferous species. These values ranged from a low of 6.4 percent for 1-year-old western white pine needles to 13.3 percent for 1-year-old lodgepole pine needles. Measurement of ether extractables provided a comparison of volatile constituents of several fuels.

Several fuels were analyzed in the oxygen bomb calorimeter to investigate the effects of age of foliage, site, and season of year on the heat of combustion. The current study of spring foliage complements previous work with foliage collected in autumn.

The physiological development of cheatgrass was followed during the fire season. Color changes in the vegetation as plants progressed from the green to a cured state were recorded periodically with movies and still photos. The film record was supplemented by weekly determinations of moisture content.

Fire-Danger Rating

The Spread Phase of the National Fire-Danger Rating System will be placed in operation in 1964 by the Forest Service and related agencies. Locally in the Intermountain area, the similarity between the Intermountain Model-8 Burning Index Meter and the Spread Phase of the National System dictated the development of a conversion program that would utilize several years' experience gained with the Model-8 system in manning and planning operations. Automatic data processing seemed the desirable way to accomplish this conversion, and accordingly a program for an IBM 1620 computer was written under contract to the University of Idaho's Computer Center. This program demonstrated a linear correlation between the two systems.

Administrative personnel from Northern and Intermountain Regions assisted in the revision of planning and manning guides and the preparation of training aids to help field personnel in the conversion to the new system. Training sessions in cooperation with private, State, and Federal fire control agencies are planned for training field personnel in all aspects of use of the new system.

The Division of Forest Fire Research is cooperating with the Western Fire Weather Coordinator in development of a national form for recording fire-weather data. Related projects include the designing of an automatic fire-weather station, testing a prefabricated anemometer mast, and compiling an inventory of all fire-weather stations in the Northern and Intermountain Regions.

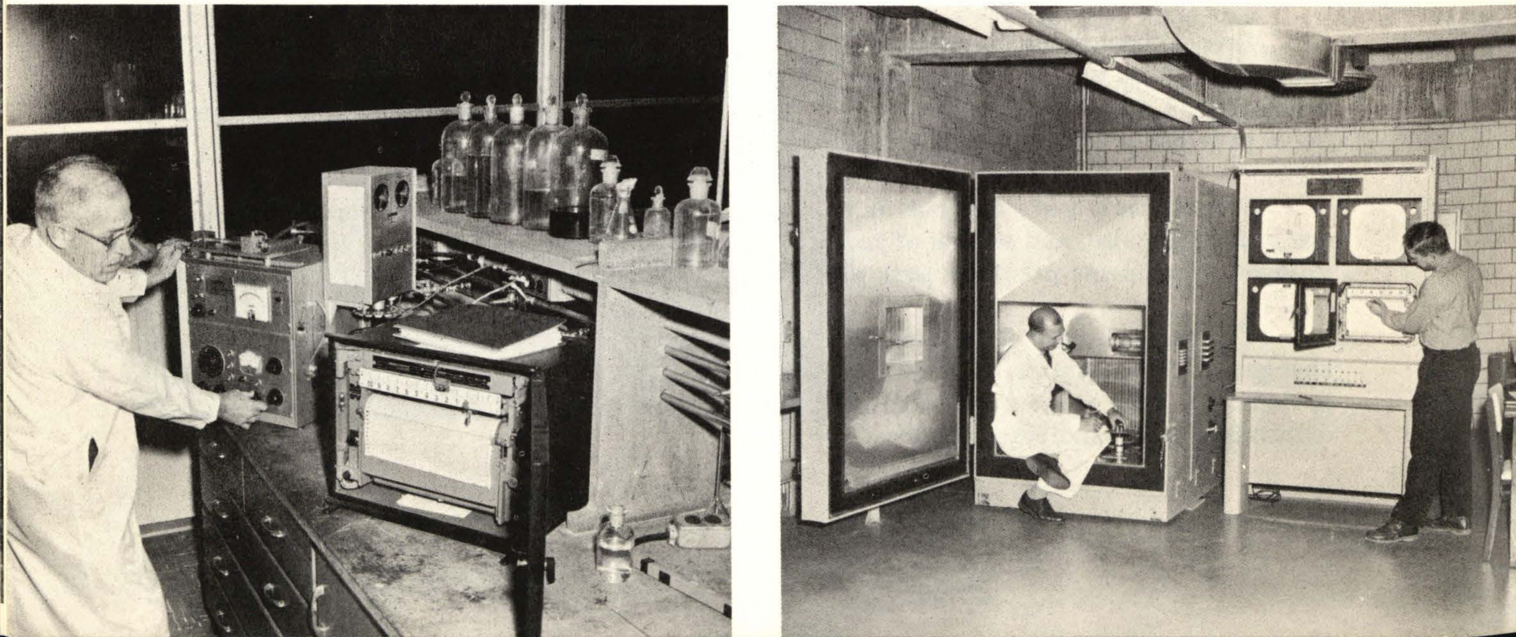

Figure 7.--*Left*, Gas chromatograph being used to determine constituents of tars and aqueous fractions of pine needles; *right*, testing and calibration of controlled environment chamber used in preparing fuel samples for tests.

Prediction and Evaluation of Fire Behavior

The Fire Laboratory's research capabilities were greatly enhanced this year by acquisition of a custom-made controlled environment chamber (fig. 7, right). In this chamber, humidity, temperature, and simulated solar radiation can be precisely controlled within wide ranges. It has already been used for studies of common forest fuels to determine their equilibrium moisture content and the rate at which they reach equilibrium. This study is one prerequisite to evaluating fuel condition in nature as a part of predicting and evaluating fire behavior.

This year we analyzed data collected during the preceding 19 years on the gain and loss of moisture in large fuels. A stepwise multiple regression analysis using 13 variables was run on an IBM 709 system at Washington State University. No single variables were good predictors for gain or loss of moisture in large fuels for 10-day intervals. The best predictors for moisture change in a given size fuel were simply amount and duration of rainfall. There was no evidence of season-to-season carryover effect as a result of drought or wet periods.

INSECTS

Studies of forest insect populations and their behavior form the foundation of our research program on bark beetles, defoliators, and insects affecting regeneration. These studies emphasize the determination of factors that affect population changes. Development of methods of control by biological, cultural, chemical, or combinations of these methods will depend upon greater knowledge of population dynamics.

MOUNTAIN PINE BEETLE IN LODGEPOLE PINE

Our first study of population dynamics was centered on mountain pine beetle in lodgepole pine. It resulted in development of a new technique for sampling populations.[2] Objectives of this study were: (1) To determine the most satisfactory sample size and location on a tree, and (2) to develop a sampling technique based on that unit. Three variables (besides size and shape of sample unit) in the development of beetle populations were considered: attack density, egg gallery length, and late larval stage brood density.

Briefly, six sample sizes were superimposed in nested fashion at each of six sample locations on each tree. The zone selected for sampling included the area 1 foot above and 1 foot below breast height. Dividing the circumferential zone into quadrants provided 16 possible sampling locations, two of which were selected randomly for each tree.

Various techniques were used to analyze the data gathered by sampling. Considering the results of the analysis and the efficacy of the samples tested, the $\frac{1}{4}$-square-foot rectangular sample was selected as the most satisfactory sample size; two samples per tree, randomly selected from 16 possible locations, will be used in further studies and for developing other sampling techniques.

BARK BEETLES IN THE NORTHERN ROCKY MOUNTAINS

Need for further studies of mountain pine beetle in western white and ponderosa pine was subjected to thorough analysis in 1963; this analysis evaluated the impact of beetle infestations in forests of these two pine species covering several million acres in the Northern Region. In some forests, tree killing from chronic epidemic outbreaks has been severe; in others, infestations have been so sporadic and light that they have killed few trees.

The amount of tree killing by the mountain pine beetle continues to be greatest in white pine stands more than 150 years old. Stands between 80 and 150 years of age have been damaged much less. In some stands of mature white pine in Idaho the beetle killed an average of 0.23 tree per acre between 1928 and 1950. In similar stands, beetle-killed trees averaged from 1 to 5 percent of the residual stands during the past several decades. Tree killing by the mountain pine beetle is hardly significant in young stands of western white pine or in stands representative of all age classes in ponderosa pine.

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[2] Carlson, Robert W. A sampling technique for population studies of the mountain pine beetle. 1963. (M. F. thesis, University of Michigan).

The beetle problem exists primarily in old growth, and its solution rests on cutting of overmature stands. The large volume of information now available in unpublished reports on the biology, behavior, seasonal history, and biotic relations of this species led to a decision against further research on mountain pine beetle in western white and ponderosa pines. This decision allowed us to start a new study of bark beetles that infest second-growth coniferous forests.

In the northern Rocky Mountain region, heavy killing of pole-size trees by certain groups of scolytid beetles has followed thinning, pruning, and other management programs. Initial effort in this project is study of the biology and ecology of the Oregon pine ips, Ips oregonis (Eichh.), in ponderosa pine. The Oregon pine ips poses the greatest single threat to more intensive management of young ponderosa pine forests in the northern Rockies.

DOUGLAS-FIR BEETLE

The Douglas-fir beetle study, which began in 1956 with one staff member at Boise, was relocated at Moscow, Idaho, this year. Sampling procedures were developed for recording seasonal and annual changes in numbers of bark beetles and associated insects. Studies now pertain mostly to population-controlling factors that affect the success with which beetles infest trees and those that destroy brood. Through such investigations we are trying to learn how damage caused by this beetle can be lessened or prevented.

By extending field phases of the study northward, we are broadening the area for application of our results. Obtaining observations and data from the far reaches of our research province helps to assure that the facts gathered will meet real needs of resource managers who must cope with this insect.

LARCH CASEBEARER

Since its discovery in Idaho in 1957, the larch casebearer, Coleophora laricella, has rapidly become the second most important defoliator in the Inland Empire. In the 7-year period, the area of visible defoliation has increased from 170 square miles to nearly 2,000 square miles.

Damage results chiefly from the feeding of last instar larvae on new foliage in early spring; in heavy infestations the foliage is destroyed almost as soon as it appears. Although no mortality of larch has been observed, despite 7 years of severe defoliation in many stands, a marked reduction in radial growth is evident. Measurements of increment cores taken from defoliated larch trees were compared to those from nondefoliated larch and from nonhost trees, namely, western white and ponderosa pine in the areas. These measurements are compared in figure 8.

In 1956, the year prior to discovery of the casebearer in Idaho, western larch in the area was adding about 4.0 mm. radial increment. By 1962, the radial growth rate was only 1.0 mm. --a decrease of 75 percent. In the same period, decline in growth of nondefoliated larch trees was 23 percent, and in the pines the growth rate decreased 10 percent. Assuming a normal decrease of, say 20 percent in radial growth of larch from 1956 to 1962, feeding by the casebearer apparently caused a further reduction of about 55 percent in heavily defoliated trees.

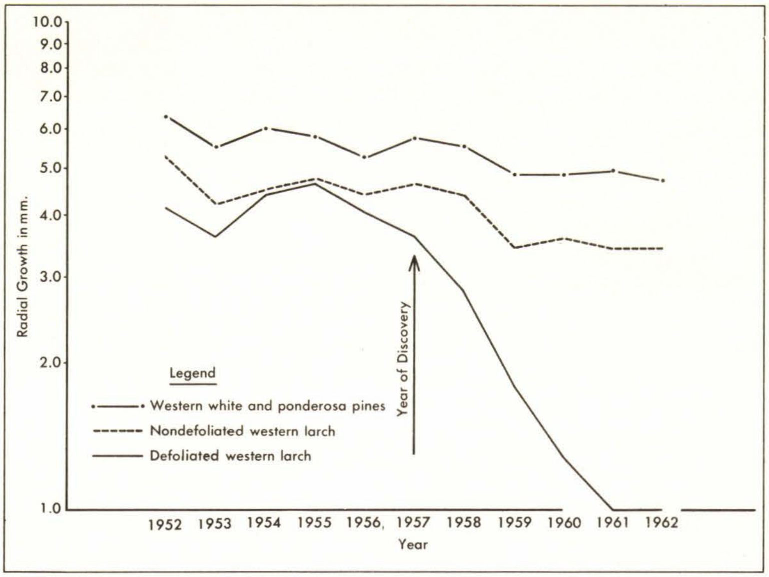


Figure 8.--Comparison of radial growth increments of defoliated western larch, nondefoliated western larch, and two pine species.

We cooperated with the Northern Region of the Forest Service in screening some chemicals to determine their effectiveness against the casebearer. In May 1963, we tested the insecticides malathion, Cygon (dimethoate), and Phosphamidon. Plots 10 acres in size were treated by helicopter at dosage rates from 1 pound per acre for Phosphamidon to one-half and one-fourth pound rates for both Cygon and malathion. Cygon was applied as an emulsion; fuel oil was used as carrier for Phosphamidon and malathion. Application rate was 1 gallon per acre.

Casebearer mortality was determined by counting the number of dead and dying larvae on 50 fascicles of needles on each of 10 sample trees per plot. Results were evaluated using a modified version of Abbott's formula, where:

$$\text{Percent control} = \frac{\text{\% mortality in treatment} - \text{\% mortality in check } (7.5\%)}{100\% - \text{\% mortality in check } (7.5\%)}$$

When only 10 trees are used for sampling in a 10-acre plot, one or two trees that receive little or no spray deposit can strongly affect the estimate of average mortality. Examination of deposit cards showed that some trees were either missed or received little spray. In practically every instance the cards matched the tree location where considerable numbers of living casebearer larvae were found. If these trees are discounted, all insecticides achieved excellent control--even those applied at the rate of only one-fourth pound per gallon per acre.

In September, further tests were made against fall feeding (second instar) casebearer larvae, using technical grade malathion without a carrier. Approximately 60 acres of heavy infestation were sprayed by helicopter at a dosage rate of about 1.4 pints per acre. Larval mortality, checked 1 week later, indicated that the test was successful. Branch samples collected at three crown levels from each of 10 trees showed no surviving larvae. However, despite the apparent success, this test is considered exploratory. Additional well designed tests are required before dosage requirements and application techniques can be determined.

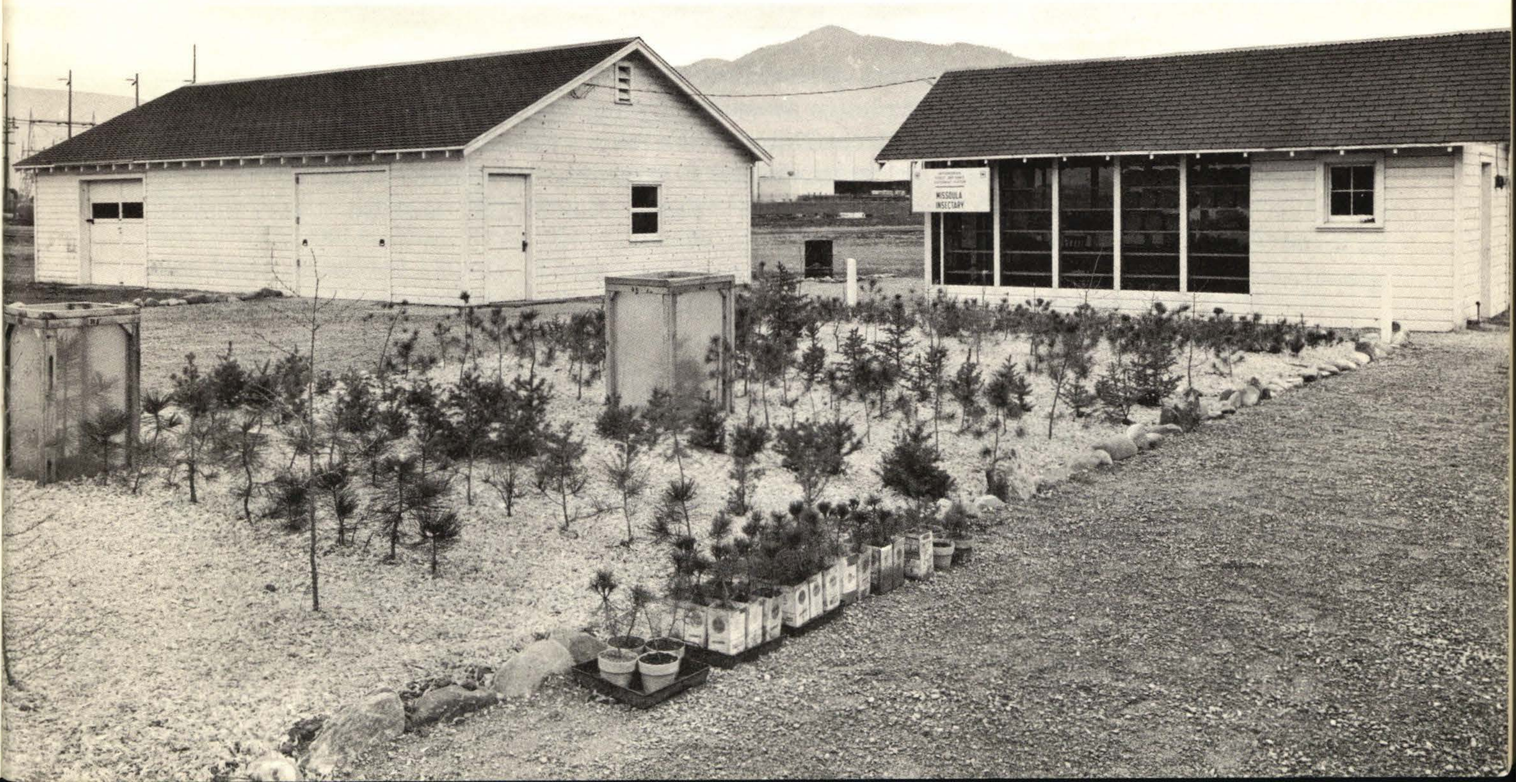
INSECTS AFFECTING REGENERATION

Fifty percent of the commercial forest land in the northern Rocky Mountains supports trees in seedling, sapling, and pole-size age classes. In the next 10 years, 80 percent of the 100,000 to 150,000 acres planned to be cut will be harvest cut (or clear cut). Some of this acreage will regenerate itself naturally, but 50,000 acres will have to be planted during the next 5 years. To achieve this planting goal, nursery production was estimated to reach 6 million trees in 1963. The transformation of forest land from sawtimber to seedlings is expected to change some of our forest insect problems.

To align our forest insect research program with the problems of the forester in managing increased acreages of young trees, we began, in the spring of 1962, a study of insects that affect the regeneration of northern Rocky Mountain conifers. During the past 2 years we have been critically examining many of the plantations and naturally regenerated stands throughout the region to determine the nature and relative severity of insect problems. Information gathered in these examinations is now being used in preparation of a problem analysis and in the establishment of priorities for selection of forthcoming studies.

A principal problem will be to determine exact identification of many insects that will appear in forest tree nurseries and plantations. On young trees in the small nursery adjacent to the Forest Insect Research insectary at Missoula (fig. 9), and on potted trees in the insectary itself, immature stages of unknown pests can be reared to adulthood for identification. At the same time, we can observe their habits and behavior for leads toward future control. To prevent insects from escaping during rearing, the trees are enclosed in Saran plastic-covered sectional wooden cages.

Figure 9.--Insectary and nursery plot, Missoula.



DISEASE

Research on native rusts was started as a project 2 years ago, centered at Logan, Utah. Now our two-man research team, chartered with responsibility for conducting and coordinating research on these diseases at the western Forest Service experiment stations, is functioning in line with a project analysis recently prepared to cover needs for research on native stem rusts in the West.

Genetics research on forest trees usually requires many years to achieve any objective set at its inception. Our white pine blister rust resistance project, conducted cooperatively with the Northern Region, completed its 13th year in 1963 and thus has reached the halfway point in its program to develop western white pine planting stock resistant to blister rust. If we can continue on schedule, by the year 1985 we will start to produce seed in commercial quantities for planting blister rust resistant forests for the future.

Major emphasis in operational control of white pine blister rust, other than genetic resistance, has shifted to uses of antibiotics in western white pine forests. This year the project on diseases of the white pine forest type directed major effort toward search for immediate answers to some pressing problems associated with this program of antibiotic control.

NATIVE RUSTS OF WESTERN CONIFERS

Project Analysis and Research Program

according to a previous guess written down elsewhere

Lodgepole, ponderosa, and Jeffrey pines, Engelmann spruce, and subalpine fir are the conifers most damaged by native rusts in the West, according to estimates made in planning a program for this project. From the Great Plains to the Sierra Nevada, rust fungi rank below dwarfmistletoes but greatly reduce forest production? More than 50 species of native rust fungi are known on conifers west of the Great Plains. From an economic standpoint they may be considered in three groups:

1. Most species cause needle rust that partially defoliates trees during years favorable to infection. In the Western States, damage from this source appears to be negligible.

2. Some cause stem rust on conifers that have little present use as lumber or poles. Examples are the rusts of pinyon, juniper, and Arizona cypress.

3. About nine rust diseases affect stems of more important conifers. The native rust project is concentrating on these. econ unimp

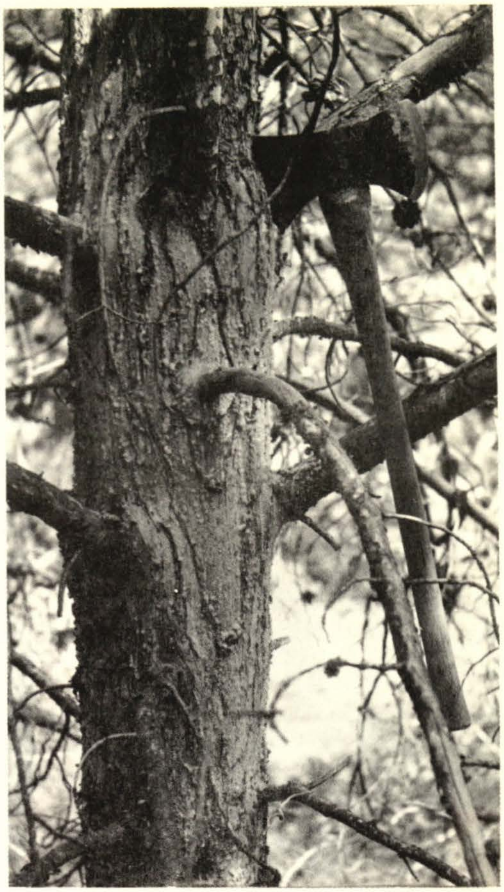


Figure 10.--Comandra rust canker on lodgepole pine. Bark removal by rodents in successive years around the dead branch near the center marks the yearly growth of the fungus.

(how)

About half of our effort in this project is devoted to the canker rust caused by Cronartium comandrae (fig. 10). Comandra rust is abundant on lodgepole pine in Wyoming, southern Montana, southern Idaho, northern Utah, and Colorado, and occurs (though in less damaging amounts) on lodgepole and other hard pines over much of North America. Chief objectives of field and laboratory studies are (1) to determine the history and causes of comandra rust outbreaks, and (2) to develop techniques for predicting and finally controlling damage. Laboratory and greenhouse studies center on responses of the fungus to environmental conditions.

why do

The limb rusts have second priority in this project. The causal fungi grow systemically in their pine hosts, kill branches as they progress through a crown, and eventually kill the tree (fig. 11). They form no cankers. At least three fungi are involved; their classification is yet to be worked out. Inoculations on pines and other hosts are underway because complete knowledge of the life cycle of each fungus is necessary for a rational approach to studies of outbreaks and damage and to long-term control measures. Growth of limb rust fungi within their hosts is also being examined closely. These rust fungi differ radically from all rusts studied previously, and location of their growth would affect chemical control.

Seven other stem rusts on important western conifers are:

1. Stalactiform rust of hard pines, particularly on lodgepole pine.

2. Western gall rust of hard pines, including a widespread "albino" form on ponderosa pine.

3. Coastal gall rust of hard pines (in California).

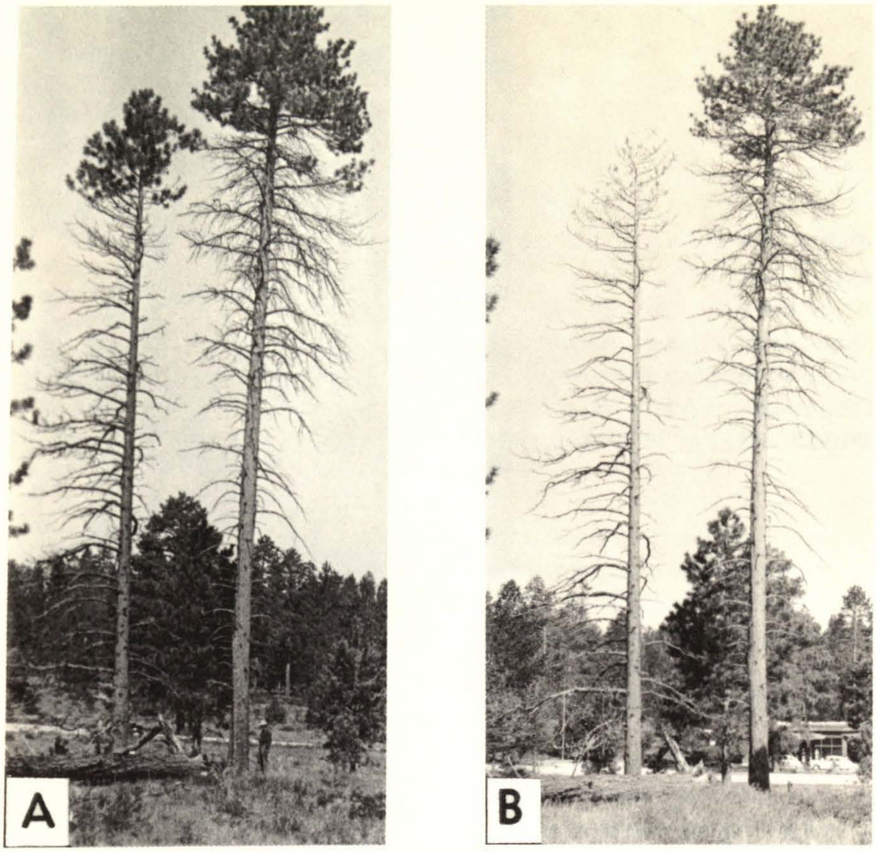


Figure 11.--A, Ponderosa pines infected by limb rust; B, the same trees after a 5-year interval. Three years later the right-hand tree was removed because of bark beetle attack, which commonly follows limb rust.

4. Sweetfern blister rust of hard pines (not common in the West).
5. Fir broom rust.
6. Spruce broom rust.
7. Incense cedar rust.

Currently these receive little attention, although some are included in greenhouse experiments and in histological studies. For the first three, basic knowledge of host alternation is scanty. For all of them, very little information is available about susceptible tissue, host range, growth rates, damage potential, conditions that favor infection, or practical control methods.

BLISTER RUST RESISTANCE

Research and developmental work in the long-range program for breeding blister rust resistant western white pine were aided materially by occurrence of a bumper white pine "flowering" year. Heavy ovulate and staminate flowering so accelerated developmental test crossing that four test cross-pollinations were completed on a total of 111 new trees--almost double the number of selections tested in any previous season.

Developmental Work

Developmental work is performed by Station personnel in a cooperative program with the Northern Region. A scientist-technician group annually devotes about $4\frac{1}{2}$ man-years to the practical aspects of mass production of relatively resistant white pine planting stock.

The basic breeding scheme leading to production of rust resistant stock includes several steps. The following tabulation shows what progress has been made on each step to date.

Steps in Breeding Scheme	Progress through 1963
1. Selection of rust-free candidates in natural stands; 400 wanted	385 located
2. Test crossing of candidates	310 test crossed
3. Progeny testing of F_1 seedlings from candidates	210 candidates now under test, 170 with sets of 4 crosses inoculated once or more
4. Reselection of candidates for general combining ability	25 to 30 reselected out of 110 fully or tentatively appraised
5. Remating general combiners within elevational zones	14 reselected candidates have been remated in 7 F_1's
6. Selection and conservation of surviving F_1's	3 F_1's involving 6 reselected candidates are now conserved in breeding arboretum
7. Establishment of F_2 seed orchard	Grafting scheduled to begin in 1970; rootstocks are under production for 1966 establishment

Research Work

Advanced generation breeding.--Resistant F_1 seedlings from early, experimental progeny tests are preserved in an experimental arboretum, where the first female strobili were produced at age 9, first male strobili at age 10. By 1963 we had been able to attempt 63 F_2 crosses among pairs of F_1 survivors, all but 3 of them during the bumper 1963 flowering season. Another 475 backcrosses were attempted on about 450 young trees, using stored pollens from one or the other of the parents of the F_1 because very few seedlings produced male strobili.

The first thimbleful of F_2 seed was obtained and planted in 1961. Now F_2 production and testing are well underway. We need information to verify gain in resistance between the F_1 and F_2 generations; this gain is now predicted at 20 percent in survival, or from 30 percent surviving F_1's to 50 percent surviving F_2's.

Interspecies breeding.--Attempts to produce hybrids among Haploxylon (five-needled or white) pines are also continuing. To date, 142 interspecies crosses have been attempted; 70 putative hybrids are under test. We have been testing chiefly for climatic adaptation, but a few putative hybrids have been subjected to artificial inoculation preliminary to resistance testing. These hybrids will constitute a reserve of germ plasm, possibly of importance in the advent of a new or different race of the blister rust fungus.

Biochemistry of rust resistance.--We have continued comparative biochemical studies of rust-susceptible and resistant white pines, including gas-chromatographic analyses of terpenes and resins and spectrophotometric analyses of phenolic compounds. Infrared absorbance tests support earlier paper-chromatographic analyses and indicate association of an unidentified but discrete phenolic compound with resistance. Studies on isolation and testing of the phenolic are in progress.

DISEASES OF WHITE PINE AND ASSOCIATED SPECIES

Dwarfmistletoes

Infection in lodgepole pine reproduction.[3]--Spread and intensification of dwarfmistletoe into young lodgepole pine stands from adjacent infested mature stands were studied in cooperation with the Rocky Mountain Forest and Range Experiment Station. Analysis of data from 79 plots in young stands in Colorado, Montana, and Wyoming revealed: (1) 3, 9, 18, and 32 percent of the stems in plots 10, 15, 20, and 25 years old, respectively, supported visible infections; (2) reproduction on better-than-average sites was more susceptible to infection than on below-average sites; (3) the average maximum distance of infection into reproduction was 26 feet from the infested residual stand; (4) 14 percent of the infested plots had been infected before they were 4 years old, and 84 percent before they were 11 years old; and (5) amount of infection in the reproduction was not correlated with any of the factors measured in the residual stand, such as degree of infection.

Analyses of results support the following recommendations for silvicultural control of lodgepole pine dwarfmistletoe:

Harvest lodgepole pine by clear cutting in large compact patches.

Locate borders of clear cuts in healthy stands wherever possible.

Remove all infected lodgepole pines left within the clear-cut areas before reproduction is established.

Sanitize infected reproduction.

Incidence in western spruces.[4]--In another study in cooperation with the Rocky Mountain Station, herbarium collections of dwarfmistletoes of spruce were examined and on-the-ground inspections were made of spruce stands reported to be infected. The western spruce dwarfmistletoe, *Arceuthobium campylopodum* f. *microcarpum*, is known only from Arizona and New Mexico where it seriously damages *Picea engelmannii* and *P. pungens*. All of the numerous reports of this form of dwarfmistletoe on western spruces at other locations were actually crossovers of other dwarfmistletoe species or forms. These other dwarfmistletoes are *A. americanum*, *A. campylopodum* f. *laricis*, *A. campylopodum* f. *tsugensis*, *A. douglasii*, and possibly *A. campylopodum* f. *cyanocarpum*, and are the bases for erroneous reports of *A. campylopodum* f. *microcarpum* in other Western States over the past 50 years.

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[3] Hawksworth, Frank G., and Donald P. Graham. Spread and intensification of dwarfmistletoe in lodgepole. Jour. Forestry 61: 587-591. 1963.

[4] Hawksworth, Frank G., and Donald P. Graham. Dwarfmistletoes on spruce in the Western United States. Northwest Sci. 37: 31-38. 1963.

ENGINEERING

Our published report on studies of pipeline transport of wood chips dealt strictly with engineering considerations. It is being supplemented by a study of economic feasibility of hydraulic means of chip transport, particularly in isolated areas where no other system of transport exists. This economic study clearly reveals necessity for much more basic engineering research. Particularly we need engineering design criteria to help determine reliability of performance and to establish reliable cost figures related to (1) friction losses inherent in this mode of transportation, (2) feasible concentration of chips to be transported, (3) costs of pumps and pumping stations, and (4) the mechanisms for getting chips into pipelines in economical concentrations. Once these cost figures are established, we can proceed with the economic studies.

A related study now underway is investigating the change in moisture content of wood chips immersed in liquid when they are subjected to change in pressure. Preliminary examination showed that moisture content increases with pressure until chips are saturated; however, lodgepole pine chips lose moisture when pressure is released. As this phenomenon will affect the amount of water required for transporting the chips and for their subsequent pulping, it will need thorough study.

This year we observed numerous logging operations, especially on steep slopes, with the object of recording data that will help analyze their efficiency. Major elements in logging are accomplished by varied alternative sequences. As this study progresses, we are testing several techniques for gathering needed data. We need a technique that will record uniform types of information accurately, cheaply, and permanently--and with minimum disturbance of the logging operation being studied.

The usual time-and-motion type of study has not proved adequate, but use of a time-lapse camera appears to be unusually promising. Photographs provide a source of engineering information that can lead to more efficient ways of performing logging operations; they also suggest safer methods of performing both manual and machine operations.

We are attempting to devise a numerical index of erodibility for major soil types in this region--especially those that are found most frequently on steep slopes. We have devised and are experimenting with apparatus for measuring movement of sediment resulting from application of simulated rainfall on samples of soils having specified compaction and reposing at specified degrees of slope (fig. 12). Results of these soil analyses would help in designing systems for holding soil in place during early stages of revegetation projects.

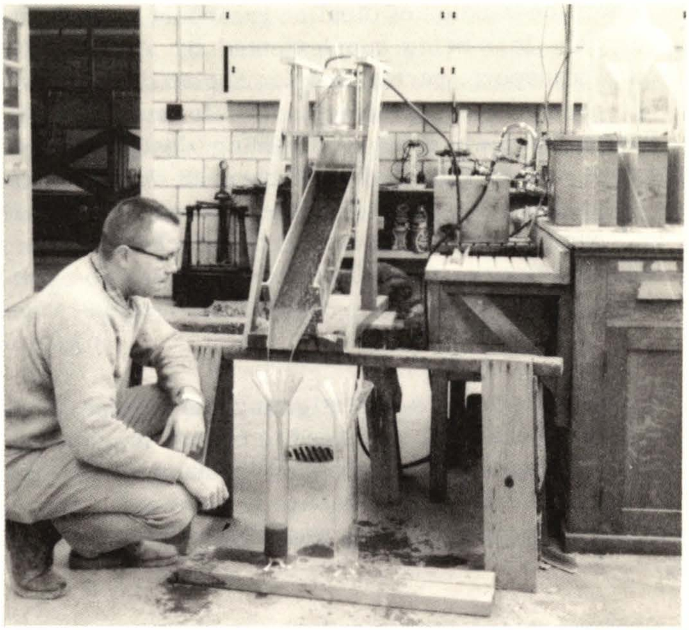


Figure 12.--Specially designed apparatus for measuring erodibility of forest soils under various degrees of mechanical compaction and slope.

UTILIZATION

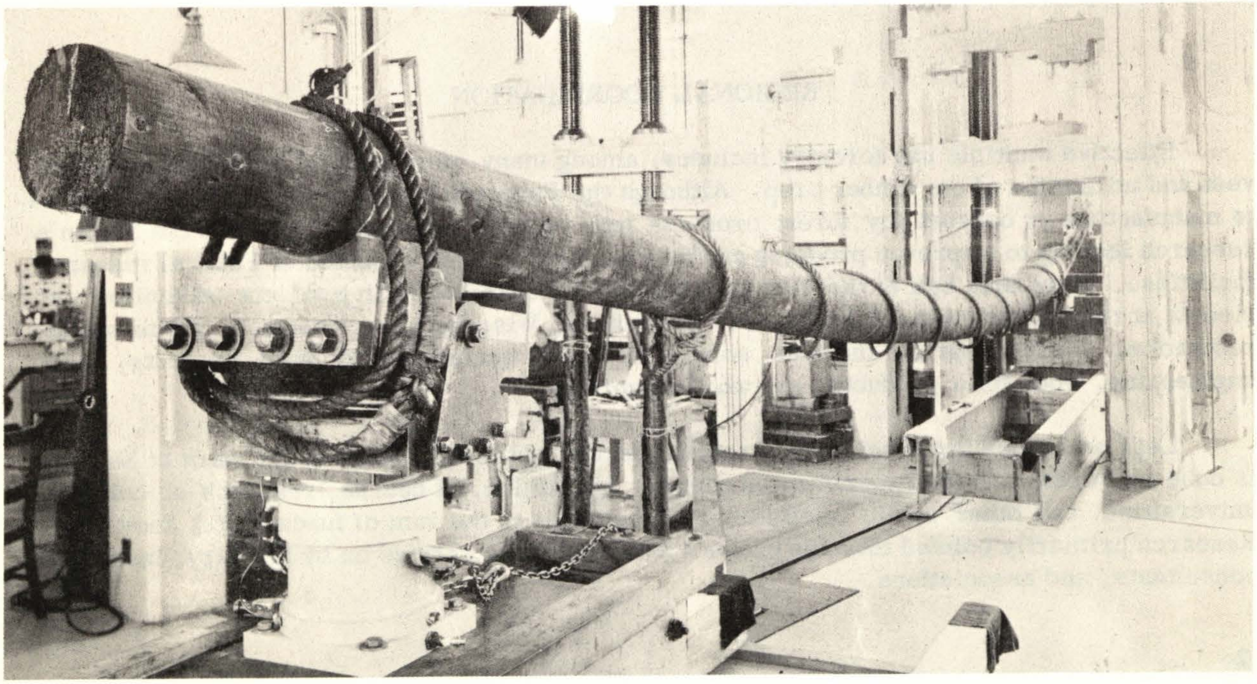
STUDIES OF GROWTH AND WOOD QUALITY

Some research on problems in utilization requires specialized analytical study--the kind done in the laboratory with the microscope and other analytical apparatus. Studies of wood quality are in this category.

Spiral grain.--In past years we reported on observations of spiral grain. In 1963, the pole twist study at Libby, Montana, was completed, twist data were summarized, and the bending strength for a sample of the test poles was measured at the Forest Products Laboratory (fig. 13). The test data on bending strength, although inconclusive because of the limited sample, clearly indicate that right-spiraled poles are nearly as strong as straight-grained poles. Left-spiraled poles, on the other hand, are significantly weaker than either straight-grained or right-spiraled poles. The average ratio of bending strengths of spiral-grained to straight-grained poles of two leading species is:

	Right spiral	Left spiral
Douglas-fir	0.91	0.46
Western larch	.88	.59

Figure 13.--General view of machine test arrangement used with spiral-grained poles. This pole is stressed to its maximum load.



The analysis of available twist data so far neither confirms nor refutes the hypothesis that direction of spirality is associated with changes in growth rate. Present limitations of laboratory techniques inhibit satisfactorily precise measurement of growth rate changes.

Intrinsic property studies.--Through a program of cooperative aid, the College of Forestry at the University of Idaho is undertaking an analysis of quality properties of western redcedar. This project is studying how various forest environment factors such as latitude, elevation, and site influence wood texture. Texture is estimated by measuring tangential cell diameters. Fieldwork for the present study has been completed and sample regressions have been calculated.

Using data furnished by this Division, the Forest Products Laboratory developed an equation relating the specific gravity of increment borings of western larch to average tree specific gravities. The equation is:

$$Y = 0.27429 + 0.434X_1 - 0.00199X_2$$

in which Y is average tree specific gravity, X_1 the increment core specific gravity, and X_2 the tree diameter at breast height.

Studies of drying.--The joint study by the Forest Products Laboratory and Intermountain Station of high-temperature drying of lodgepole pine and western larch poles shows that drying time can be greatly reduced. Poles were dried at the J. Neils Division of St. Regis Paper Company high-temperature kilns at temperatures ranging from 180° to 200° F. in 2 to 3 days and later were satisfactorily treated with preservatives.

As a part of our activities in the Forest Products Research Society, we prepared a comprehensive national report on developments in wood drying. The Station continued participation in studies and demonstrations for the national log and tree grade development program.

REGIONAL COORDINATION

Effective multiple use forestry includes, among many other things, the systematic harvest and utilization of the timber crop. Although the Forest Service does not operate factories to manufacture or convert any forest products into useful commodities, much of the Nation's research leading to improved products and new uses for wood is centered at Federal research facilities. More than half of the Federal program for research is in products utilization carried on at the Forest Products Laboratory in Madison, Wisconsin, by scientists of international reputation. This program includes studies of wood quality, solid wood products, wood engineering, wood fiber products, and wood chemistry.

Less ambitious but equally important research, which complements the work at Madison, is done by Forest Service experiment stations. In addition, of course, research at colleges, universities, and other public institutions further adds to the sum of fundamental knowledge. Research primarily pointed towards product development is carried on by industry, industrial consultants, and associations.

Our mission at Intermountain Station is to improve the regional timber utilization technology by the study of problems and by promoting application of results of research. Effectiveness of this program depends upon (1) selection of highest priority problems, (2) fullest possible coordination of Federal, State, and industrial research programs, and (3) acceleration of adoption of research findings by timber-using industries. Close liaison between research at Forest Products Laboratory, the Station, and industry is essential.

IMPROVEMENT OF UTILIZATION

Need for such a coordinated program is accentuated in this area by the importance of timber-using industries to the economy. This research is especially timely because of changing composition of the available timber supply, increasing competition between wood and other construction materials, and the rapidly changing technology in forest products utilization.

The year 1963 witnessed significant expansion by the wood-using industry in this region. A new plywood mill started operations in Montana; two others were expanded or rebuilt. Ground was broken for another plywood mill in Idaho, and companies have inquired about other possible locations. Several lumber mills have added new dry kiln capacity; one mill has expanded its high-temperature dry kilns. Another company completed a multimillion-dollar planing mill and dry storage operation. Two companies have expanded their laminating operations, and a new pulpmill is in the advanced design stage.

In each of these developments, as well as in others not listed, Intermountain Station has been asked to provide technical advice and guidance. Our advisory function in 1963, as in past years, has proved to be valuable both to industry and to forest land managers. In numerous — instances, research has directly supported RAD and ARA programs by reviewing forest-based proposals.

ECONOMICS

FOREST SURVEY

The national compilation of timber inventory statistics dominated activities of the Forest Survey project in 1963. Our entire Forest Survey staff was engaged in bringing up to date information on the timber situation in the eight Rocky Mountain States and western South Dakota. This national compilation of data on timber supplies at about 10-year intervals is a regularly scheduled part of the nationwide Forest Survey. The last scheduled reappraisal of the Nation's timber situation was published in the 1952 Timber Resources Review. Since the reappraisal in 1952, we have inventoried the States of Colorado, Wyoming, Utah, Arizona, and New Mexico for the first time, using statistically designed surveys. These new inventories were made in cooperation with the Rocky Mountain, Southwestern, and Intermountain Regions.

One of the most important changes that occurred within the 10-year period was the substantial increase in timber cut. The total cut rose from 429 million cubic feet in 1952 to 683 million cubic feet in 1962, but the relative standings of individual States did not change greatly. The percent of increase in total timber cut, based on cubic-foot volumes, in Rocky Mountain States between 1952 and 1962 was:

Idaho	43.6
Montana	89.4
Arizona	58.2
Colorado	21.3
New Mexico	112.1
Wyoming	48.7
South Dakota[1]	38.2
Utah	47.7
Nevada	143.4
All Rocky Mountain States	59.1

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[1] West of 103d meridian.

In the northern Rocky Mountain area, Idaho's percentage of the total cut declined a few points, but Montana's percentage increased. In the southern Rocky Mountain area, Colorado's 1962 percentage was lower than it had been in 1952, while New Mexico's was somewhat higher. The two following tables show the change in the pattern of the timber cut in this period.

Total timber cut in the Rocky Mountain States, 1952 and 1962

State	Total timber cut			
	1952[1]		1962	
	Thousand cubic feet[2]	Percent	Thousand cubic feet[2]	Percent
Idaho	188,268	43.9	270,275	39.6
Montana	117,688	27.4	222,876	32.6
Arizona	41,676	9.7	65,941	9.7
Colorado	30,970	7.2	37,556	5.5
New Mexico	18,674	4.3	39,601	5.8
Wyoming	14,631	3.4	21,756	3.2
South Dakota[3]	8,506	2.0	11,756	1.7
Utah	8,499	2.0	12,554	1.8
Nevada	221	.1	538	.1
Total	429,133	100.0	682,853	100.0

[1] From "Timber Resources for America's Future," Forest Resource Report 14. 1958.

[2] Cut from trees 5 inches d.b.h. and larger.

[3] West of the 103d meridian.

Distribution of total timber cut in the Rocky Mountain States, by major products, 1952 and 1962

State	Saw logs		Pulpwood[1]		Veneer logs		All other products	
	1952	1962	1952	1962	1952	1962	1952	1962
	Percent							
Idaho	90.3	95.9	3.0	1.1	0.8	1.2	5.9	1.8
Montana	82.2	89.4	9.4	1.2	0	8.1	8.4	1.3
Arizona	99.1	85.8	0	12.1	0	0	.9	2.1
Colorado	86.8	88.5	0	.5	0	0	13.2	11.0
New Mexico	99.6	97.4	0	0	0	0	.4	2.6
Wyoming	86.9	96.3	.6	1.7	0	0	12.5	2.0
Utah	76.5	92.4	0	0	0	0	23.5	7.6
South Dakota[2]	83.8	59.8	.4	26.0	0	0	15.8	14.2
Nevada	84.2	84.0	0	0	0	0	15.8	16.0
All Rocky Mountain States	88.6	91.8	3.9	2.5	.3	3.1	7.2	2.6

[1] Round pulpwood only; i.e., does not include pulpwood from sawmill and veneer plant residues.

[2] West of 103d meridian.

There have been some shifts in the product mix since 1952. Saw logs are still by far the most important roundwood product, but during this decade pulpwood has increased in importance in Arizona, Colorado, Wyoming, and western South Dakota. The cut of pulpwood in Idaho and Montana declined in the 10-year period, but total pulp production has increased by greater use of mill residues. Montana's veneer industry came into existence after 1952, but in 1962 it accounted for 8 percent of the timber cut in that State. The output of other forest products (poles, posts, fuelwood, excelsior bolts, converter poles, and miscellaneous industrial and farm timbers) has generally declined in percentage since 1952 in the northern Rocky Mountain States (Idaho, Montana, Wyoming, and western South Dakota); but in the southern Rocky Mountain States, both upward and downward changes have occurred.

Photogrammetric Studies

An important study completed this year compares several photogrammetric means for dividing or stratifying the forest for sampling purposes. Any population, whether it be forests or people, can be sampled more efficiently if it can be divided into somewhat homogeneous groups. The problem in sampling the forests has been to find readily recognizable strata having minimum within-group variation. In this photogrammetric study, the study area was classified on aerial photos into cubic volume, stand-size class, species, and stocking strata. Findings indicated that volume classes are the most effective means of photo classification. They were nearly twice as effective as stand-size and density classes, and nearly three times as effective as species or density alone in stratifying for volume sampling. Photo cubic-volume classes were also more helpful than the others in selecting both high risk sawtimber and young stands needing management treatment, such as thinning.

A second photogrammetric study developed a new technique for accurately estimating depth of small mountain lakes. By using standard aerial photos at 1:20,000 scale available from most land managing agencies, this technique makes possible, at extremely low cost, improved inventory of a wildland resource important alike to recreation planners and resource managers. Small lakes, often in areas remote from access roads, provide good fishing and camping sites; hence their importance to recreational development.

Composite aerial volume tables for conifer stands in the Mountain States were published this year and are being tested. A study to develop aerial photo methods of estimating stand basal area has been started.

ECONOMIC STUDIES

The economics research staff continued to concentrate on two major studies: (1) white pine management in the Inland Empire, and (2) multiple use management of forest and range lands in Utah.

Work to date on the white pine study has demonstrated the need for more nearly complete and accurate information on the cost of timber management cultural activities such as controlled burning and planting. To meet this need, the Northern Region and Intermountain Station established a committee to study costs of timber management. The committee is working to develop better cost records and also to set up tighter and more nearly adequate operational standards for preparing such records on the National Forests.

We reviewed the needs for resource data for management planning and economic analysis in cooperation with the regional Timber Management staff at Missoula and with the Coeur d'Alene National Forest.

Multiple Use Economics Study

The first phase of a multiple use economics study--a statewide survey of the relation of the wild land resources to the economy of Utah--was well advanced by the end of this year. The primary objective of this study is to gain an understanding of the broad patterns of renewable resource development within the State; this includes historical trends, current conditions, and the circulation of harvested resources within the State and beyond its borders. The second objective is to develop an estimate of the economic value derived from each of the State's natural resources.

The second phase of this study, which was started this year, is designed to bring into focus a geographic unit of some 500 square miles in southern Utah. The primary purpose of this phase of the total study is to recognize and describe all the factors--economic, social, and special--that bear upon multiple use considerations in this land unit. This phase involves investigation of the contribution of each resource in the unit, past and present, the effects of use upon condition of the land, related economic and employment patterns, the anticipated influence of proposed projects (highways, reservoirs, etc.) on the unit, and the potential contribution of each resource in the unit. The intensive study of this small area is constantly oriented to relation of the study area to the whole State.

RECREATION

Recreation research this year was directed primarily toward problems of the management of campgrounds in forest areas. Our research paper, "Campgrounds for Many Tastes," pointed out that if campgrounds are to provide maximum benefits and enjoyment, land managers must recognize that campers have a great diversity of needs and that the camping facilities suited to these needs will vary accordingly. To serve this whole range of needs will probably require the efforts of several public agencies, plus private enterprise. The paper proposes a classification of campground types that may help recreation planners meet the full spectrum of campers' needs, and suggests diverse types of campgrounds, ranging from simple back-country sites to rather elaborate facilities.

To test the effectiveness of management procedures for keeping camping areas attractive and pleasant, one campground study has been started in Cache National Forest, and preliminary fieldwork and planning have been done for additional studies of campgrounds on the Sawtooth and Caribou National Forests. These three National Forest campgrounds represent a variety of classes of use, vegetative cover, soils, and climate.

The study of Crystal Springs campground in Cache National Forest is a cooperative project with the College of Forest, Range and Wildlife Management at Utah State University. Campground construction was started late in 1963 and use will begin in 1964. Initial measurement of vegetative cover was made this year; hence we can study the trend of growth and survival from the beginning of use of the area. This campground is about one-fourth mile south of the Logan Canyon highway (U.S. 89) near the Bear Lake scenic overlook. It provides 25 camping spots in an aspen-conifer stand. It is built to standard Forest Service specifications and offers the attractions of quiet, secluded location and such conveniences as adequate spacing between individual camping spots, toilets, picnic tables and grills, and running water.

Contemplated treatments include limited irrigation and fertilizing. Periodic remeasurement will enable us to trace the effect these treatments, separately and in combination, will have on abundance of the native grasses and low shrubs that contribute to the desirability of a camping site. We also need to learn whether these treatments, particularly watering, are economically feasible for use in campgrounds in a semiarid region.

RANGE MANAGEMENT

MOUNTAIN HERBLAND, BRUSHLAND, AND ASPEN RANGES

Problems in managing important types of mountainous rangelands that provide summer grazing for livestock in the Intermountain region are being studied in cooperation with Utah State University, National Forests, and livestock owners. The studies include such problems as determining how slope steepness influences range usability; developing better grazing practices for improving both production and utilization of forage on mountainous rangelands; and gaining understanding of the basic ecology of the various types of native range and growth characteristics of individual species pertinent to sound management.

This year, records from Horseshoe Flats, a subalpine location on the Wasatch Plateau, were analyzed for long-term ecological significance. The records demonstrated that some plant communities had undergone drastic successional changes since 1915, when study plots were established; but other plant communities have remained relatively stable (fig. 14).

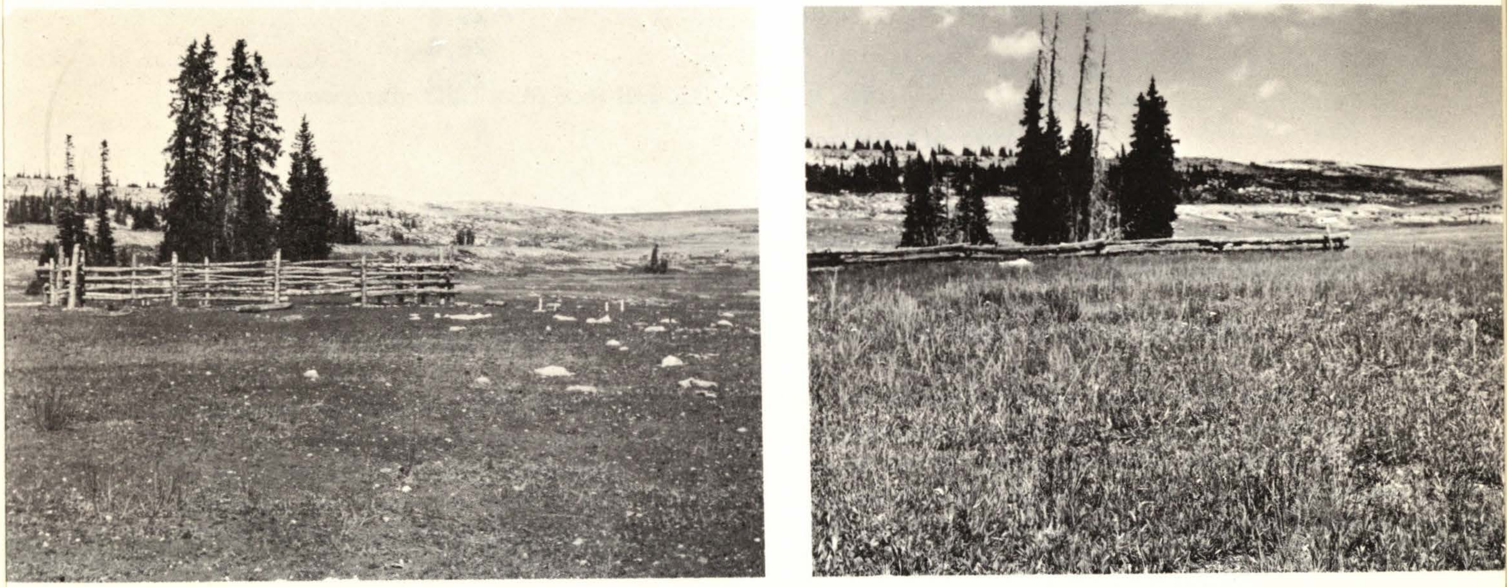

Figure 14.--Left, This subalpine study plot on the Wasatch Plateau was established by A. W. Sampson in 1915, and photographed in late fall after heavy grazing by sheep. The vegetation was characterized by penstemon and yarrow and an abundance of annual species; right, in late August 46 years later the vegetation shows favorable effects of reductions in grazing pressure. Plant cover has increased under both reduced grazing and complete protection. Annuals have practically disappeared. Penstemon is still a dominant species of both protected and grazed areas. Stipa lettermanii, a grass of limited palatability for sheep, has greatly increased on grazed range; Stipa columbiana and Geranium richardsonii, palatable species, have increased in the exclosure.

A continuing problem, widespread on mountain rangelands, has been rather large populations of pocket gophers (Thomomys talpoides wasatchensis) and the damage they cause to numerous valuable forage plants. During the past 3 years, Intermountain Station has participated in a cooperative study of gopher control (by using 1080-poisoned grain) and its results; other participating agencies were the Bureau of Sport Fisheries and Wildlife, the Utah Cooperative Wildlife Research Unit, and Utah State University. This study was made in the Monte Cristo area on Cache National Forest and adjoining privately owned land.

In this experiment, large populations of pocket gophers were reduced about half by 1 year's intensive treatment. Continued treatment during 3 additional successive years kept population approximately at the 1-year control level but failed to reduce population further by any significant amount. After a single year of no control, gopher numbers doubled and were about as large as they had been prior to treatment, regardless of length of treatment. The following tabulated population index,[5] determined by saturation trapping of sample areas during a 3-day period in 1961 and again in 1962 (when no treatment was applied) indicated the following results from treatment:

Years of treatment	Population index (per acre)	
	1961[1]	1962[2]
0	27.0	39.3
1	14.0	30.0
2	14.5	29.3
3	13.5	26.0
4	12.5	28.0

[1] Last year of treatment.
[2] No treatment applied.

Apparently some more effective method than poisoning is needed if gopher control is to be practical on rangeland.

DESERT SHRUB, SAGEBRUSH-GRASS, AND PINYON-JUNIPER RANGES

These three types of range comprise some 150 million acres of low-elevation rangelands in the Great Basin and Colorado River drainages of Nevada, Utah, and western Wyoming. This year our studies were restricted to the desert shrub and sagebrush-grass types. Studies at Benmore Experimental Area, in cooperation with Utah State University and the Wasatch National Forest, have emphasized management of seeded crested wheatgrass (Agropyron cristatum) range in the sagebrush-grass zone. An allied problem is invasion of this zone by undesirable brush and by the poisonous annual range weed halogeton (Halogeton glomeratus).

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[5] Richins, Voit B. Evaluation of the control of pocket gophers on Cache National Forest, Utah. 1963. (Ph. D. dissertation) Utah State University.

Although grazing practices for optimum production of grass and cattle on spring range have been developed, reinvasion of seeded grass stands by sagebrush has proved troublesome. Rabbitbrush also has invaded, but it has not materially affected grass production.[6] Investigation of circumstances related to sagebrush invasion at Benmore under three different intensities and three systems of grazing by cattle revealed that:

1. Heavy grazing increased invasion, but light grazing did not prevent it entirely. Sagebrush seedlings successfully invaded lightly grazed pastures and ungrazed enclosures in 2 years out of 10.

2. Unusually favorable moisture conditions in spring and summer characterized years when sagebrush invaded good stands of crested wheatgrass.

3. Proximity to a seed source was the factor most closely related to invasion; 90 percent of young sagebrush plants were clustered within 10 yards of parent plants.

Similar investigation of invasion and establishment of halogeton (fig. 15) showed its occurrence at Benmore to be influenced by weather, heavy grazing, and presence of soil salts, as follows:

1. It has been most abundant in years when precipitation in spring and summer was relatively high.

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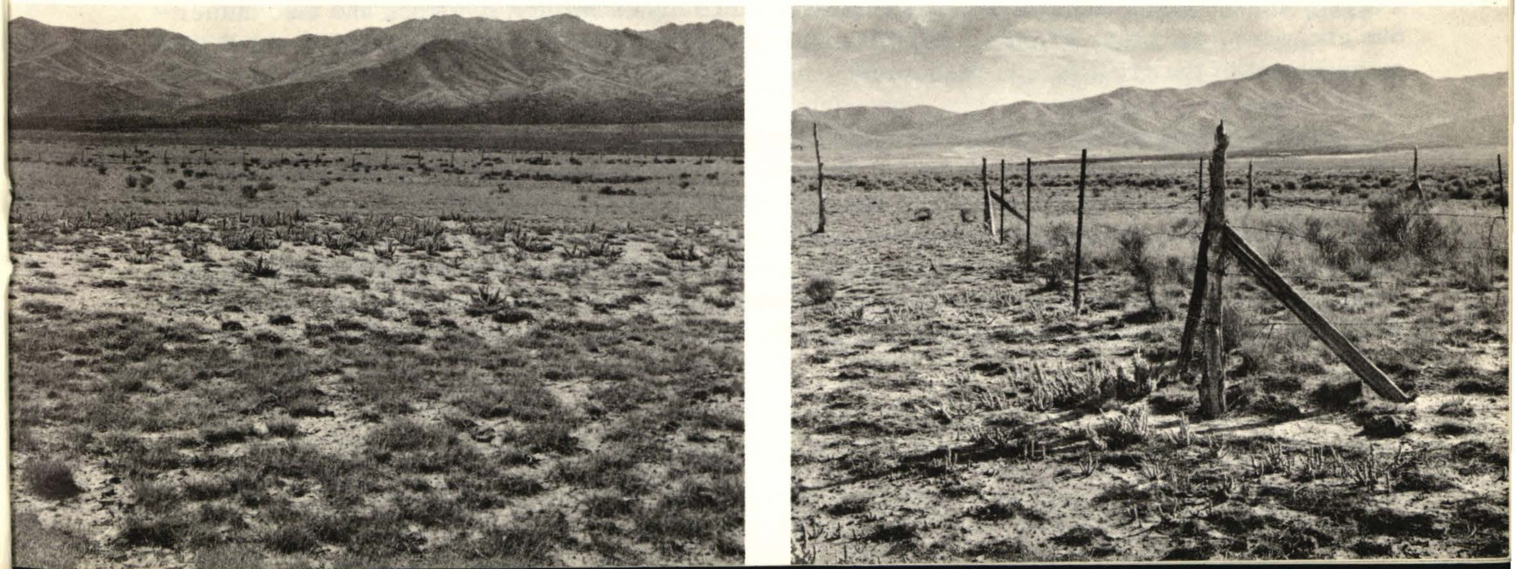
[6] Intermountain Station Annual Report, 1962, p. 37.

Figure 15.--Left, Halogeton occurred only on sparsely vegetated salty spots in moderately grazed ranges such as this where spring utilization of crested wheatgrass averaged 50 percent; right, halogeton thrived in wet years on heavily grazed range where grass was utilized more than 70 percent, but it never invaded ungrazed exclosures.



2. It has been associated with heavy grazing: widespread on ranges heavily utilized (80 percent); localized on heavily grazed spots in ranges used moderately (65 percent) or lightly (50 percent); never in ungrazed exclosures.

3. It occurred on soils containing soluble salts in excess of 0.08 percent--including concentrations up to 0.7 percent in the surface 12 inches, and up to 1.5 percent at depths of 12 to 36 inches. These concentrations evidently reduced the competitive efficacy of the grass and associated vegetation; also, cattle apparently liked the forage on salty spots.

CHEATGRASS AND SAGEBRUSH-GRASS RANGES IN IDAHO

Although the cheatgrass and sagebrush-grass types of range present somewhat different problems of utilization and management, they are closely related in that cheatgrass represents "degraded" sagebrush-grass from which perennial herbaceous species, and sagebrush as well, have been largely eliminated by grazing and fire. In best condition, these ranges produce a varied mixture of nutritious grasses and broad-leaved herbs along with dispersed sagebrush and other shrubs. In limited amounts, shrubs are considered desirable; but the usual tendency is for sagebrush to increase at the expense of herbaceous species.

We are studying how to maintain a desirable composition and high production on sheep range at the U.S. Sheep Station Experimental Range near Dubois, Idaho. We are also evaluating contrasting influences of spring, summer, and fall use. This research is cooperative with the Agricultural Research Service of the U.S. Dept. of Agriculture and with the University of Idaho.

At Saylor Creek Experimental Range, near Glenns Ferry, Idaho, we are studying cheatgrass range in cooperation with the Bureau of Land Management and local stockmen. The general management objective here is to utilize effectively the present "annual type" forage while encouraging conversion to more desirable perennials. Preliminary results reflect fairly good forage on this land but highly variable production from year to year. Young cattle have gained an average of about 1.5 pounds per day through a 7-month season. These gains vary from 2 pounds per day in spring, before the cheatgrass matures, to about 1 pound per day in the fall. Grazing capacity in the best of 3 years has been two to three times that of the poorest year.

NORTHERN ROCKY MOUNTAIN GRASSLANDS

Our studies of management of grazing resources of mountain grasslands and associated forest ranges of the northern Rocky Mountains are centered at Bozeman, Montana. On National Forests alone these lands are grazed annually by more than a million livestock and also numerous elk, deer, and other wildlife. Yet little specific information is available to guide scientific management of the great forage resource.

Initial efforts at Bozeman are directed toward answering some basic questions about the nature of the forage resource and how it is related to soils, climate, and grazing. Current studies are investigating: (1) ecological characteristics of little-disturbed mountain grasslands in Montana and central Idaho in relation to elevation, soil, physiography, and other site characteristics; (2) response of important forage species to herbage removal at different phenological stages; and (3) climatic conditions on representative grassland types, and relations between weather factors and plant development and yield.

WILDLIFE HABITAT

SHRUB COMMUNITIES IN THE NORTHERN ROCKIES

In western Montana and northern Idaho we are studying problems related to big-game habitat with the belief that timber and wildlife do not necessarily represent conflicting interests. Observations of secondary succession following old wildfires suggest a common development pattern for many forest communities.

In early years after fire, grasses and forbs are likely to dominate burned-over areas. Later, shrubby species become important; and finally trees occupy the sites. While this pattern develops, shrub communities are dominant for 10 to 25 years. Depending on their composition, some of these communities are extremely valuable as big-game forage areas. Wildfires are nearly a thing of the past; but silvicultural practices based on clear cutting followed by burning for hazard reduction and site preparation might produce kinds of shrub communities similar to those that formerly followed wildfires. If we can determine methods for assuring a desired composition, these communities would be even more valuable than those created by wildfire.

We are carefully examining old burns in the Douglas-fir zone to learn what shrub species have followed wildfires and to determine the approximate time periods involved in their development on various sites. We have found, not surprisingly, that some shrub species are restricted to specific site conditions while others show wide ecological amplitude. The studies also have revealed that the full successional cycle back to trees may be completed in less than 40 years, or it may require several centuries. Factors that control or influence length of these time periods, or rate of succession, warrant further study, for they should be manipulated purposefully in management.

DEER WINTER RANGE IN SOUTHERN IDAHO

While demands for hunting steadily increase, deerherds in southern Idaho face a shrinking habitat--particularly in critical winter range. Such activities as agricultural and urban developments, expanding highway systems, and construction of new reservoirs will continue to usurp key range areas or reduce their use by interfering with deer migrations. More important, however, is loss of productivity on these ranges caused by fires and overuse by game and livestock. Also, we are concerned about management of present choice browse species, such as stands of bitterbrush and mountain-mahogany, which appear not to be reproducing themselves. Already much winter range has deteriorated so greatly that artificial revegetation seems necessary to restore useful habitat.

Our study of revegetation of winter deer range, in cooperation with the Idaho Fish and Game Department, has been concerned primarily with seeding bitterbrush on harsh sites with granitic soils. We are now directing attention toward additional browse species, toward insect damage to bitterbrush seed, evaluation of site potential, and faster techniques for measuring browse utilization.

In addition to the insects already reported to be damaging bitterbrush seed crops,[7] Say's stink bug (Chlorochroa sayi Stål.) has been identified as preventing maturation of ripening seed by feeding on it. Eighty-five percent of the seeds checked in a study this year were killed on branches enclosed with them inside nylon mesh cages. On branches similarly caged, but to exclude insects, only 1.5 percent of the seeds were damaged, and this by an unknown agent.

Another study completed this year revealed possibilities for increasing efficiency in measuring browse utilization. Ordinarily, utilization is estimated by sampling length or weight of twigs on shrubs before and after use by game animals. We now find that the weight of a bitterbrush twig, for example, is closely related to its basal diameter (where it branches from the stem). Therefore only post-browsing measurement is necessary to estimate both initial weight (from diameter of twig base), residual weight (by clipping and weighing), and utilization (difference between initial and residual weights). This procedure, of course, is applicable only during the dormant, nongrowing season.

RESTORATION OF GAME RANGE IN UTAH

For some years we have been studying rehabilitation of depleted deer range in cooperation with the Utah State Fish and Game Department. Critical winter range in the pinyon-juniper zone has received most attention. In this zone, the herbaceous understory was largely eliminated years ago by uncontrolled grazing and was partially replaced by species unpalatable to livestock; these included juniper, pinyon, sagebrush, and other shrubs useful to deer as emergency winter food. Since then, desirable browse species have been almost eliminated by the combination of deer use and competition from pinyon and juniper trees.

Removal of the pinyon and juniper trees restores production of game forage wherever enough desirable plants have persisted. Otherwise, seeding of adapted species of shrubs, forbs, and grasses is necessary. The most efficient methods we have used for tree removal are cabling and chaining, in which up to 400 feet of heavy cable or anchor chain, looped between powerful crawler tractors, pull over or break off the trees in a swath up to 200 feet wide (fig. 16). In conjunction with this treatment, browse and herbaceous species can be broadcast-seeded from aircraft. Recently several procedures for tree eradication, combined with aerial broadcast-seeding, were compared. Comparative costs and effectiveness of treatments were:

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[7] Intermountain Station Annual Report, 1961, pp. 33-34.

Procedure	Cost per acre	Tree kill	Seed coverage	Initial seeded stand
		Percent	Percent	Percent
Cabled once	$2.00	70	35	45
Cabled twice (in opposite directions)	3.50	80	40	60
Chained once (with 40-lb. links)	2.75	80	40	70
Chained twice (with 40-lb. links in opposite directions)	5.00	90	55	85
Chained once (with 90-lb. links)	5.00	85	60	80
Chained twice (with 90-lb. links in opposite directions)	7.00	95	80	90

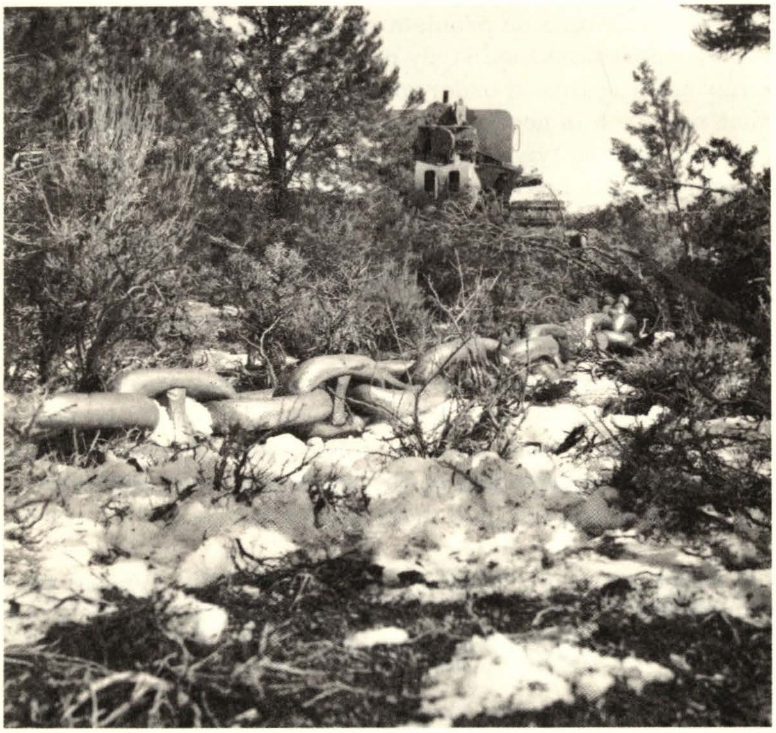

Figure 16.--Anchor chaining efficiently removes juniper and pinyon trees, and at the same time prepares a seedbed for aerially sown seed. A second chaining covers the seed and results in better initial stands.

TIMBER MANAGEMENT

Commercial forest lands in the Intermountain Station's area of responsibility are now producing at half their capacity. The present annual production of about 4 billion board feet of sawtimber products could eventually be doubled by intensive management of the commercial forest land. Though we know in a general way the needs for more intensive management, the specifics of management practices are only partly known. For example, we know that prompt regeneration is needed after clear cutting, but we do not know how to accomplish this for many situations. We know that thinning is needed to prevent overstocking--the bane of much of our forest acreage--but we do not know the precise levels of growing stock to leave when thinning stands of various ages and species growing on a variety of sites. Coordinated and integrated research in silviculture, tree improvement, mensuration, protection, utilization, and other operations is required on a broad front to provide the detailed knowledge needed for intensive management and attainment of full timber production.

Our present research projects are helping materially to supply knowledge essential for timber management. During 1963, studies in direct seeding of western white pine and western larch gave encouraging results. Studies of ponderosa pine planting on steep slopes and studies of natural regeneration of lodgepole pine on problem sites began to solve troublesome problems in management. We made a reconnaissance study of regeneration following cutting in Engelmann spruce in the Intermountain region in order to determine just how critical the regeneration problem really is and what research is needed. During the year we learned more about timber culture and growth in several forest types. And our mensuration project made significant advances in developing techniques for better measurement.

SILVICULTURE OF WESTERN WHITE PINE

Development of Young Western White Pine Plantations

Studies of 23- and 29-year-old plantations of western white pine on the Coeur d'Alene National Forest have revealed average annual growth of nearly 0.2 inch in tree diameter and about 200 cubic feet per acre in volume over a subsequent 10-year measurement period. Variation in annual volume increment from 162 to 264 cubic feet was related to variation in site quality from site index 50 to site index 70.

Plantations are less subject to overstocking than natural fully stocked white pine stands on similar sites and of equivalent age from seed. This is reflected in the greater and less skewed diameter distribution found in plantations (fig. 17).

The better spacing and fewer trees in the planted stands (from one-fifth to one-half as many trees as in equivalent natural stands) resulted in 50 to 122 percent larger average diameters at breast height, in 20 percent greater basal areas, and 30 to 60 percent greater cubic volume in the planted stands. Another white pine plantation, on the Deception Creek Experimental Forest, Coeur d'Alene National Forest, provided a better test of effects of density on early growth. Under fairly uniform site conditions, tree diameter at 23 years' age averaged 20 percent greater in plots with 73 square feet of basal area per acre (1,370 trees) than in plots with 113 square feet (2,500 trees). On the other hand, density of this range appeared not to affect growth of the larger potential crop trees.

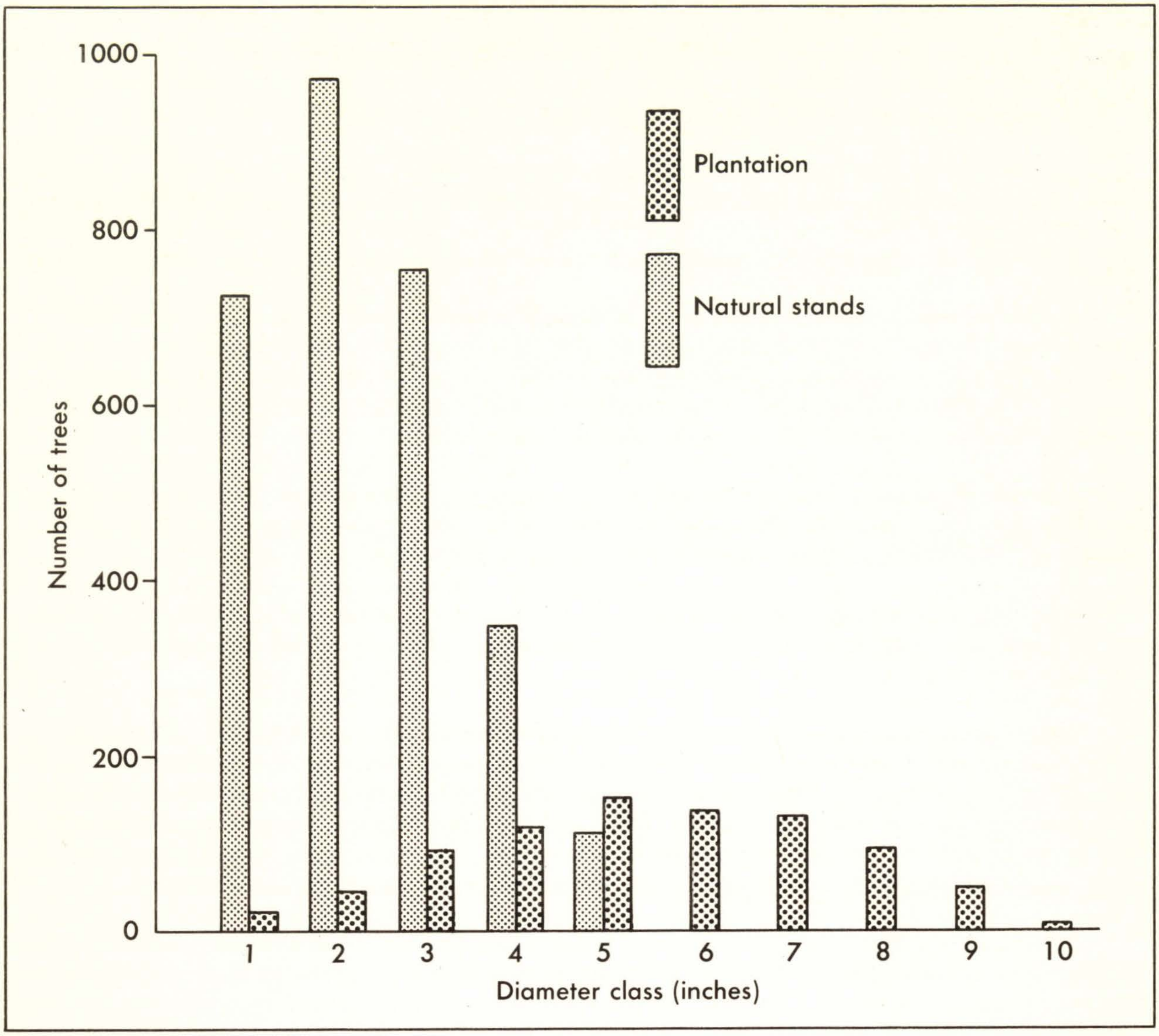

Figure 17.--Distribution of tree diameters in Cathedral Peak western white pine plantations at 33 years' age compared to distribution in natural stands.

Advantages of plantations over natural stands lie not only in faster rate of development, but also in better tree distribution, easier and less urgent application of cultural treatments, and much higher percentages of the more valuable white pine trees in dominant position.

Insect Damage in Grand Fir Cones

Observed seed loss caused by cone and seed insects exceeded 15 percent of the total crop in one northern Idaho area. Fir seed maggots destroyed 7 percent of the cones. Cone moths and coneworms infested 14 percent of all cones and caused an estimated 5-percent seed loss. Midges were difficult to detect in early stages but caused at least 3-percent seed loss. More information is needed about the influence of environmental conditions, including size of cone crops, on infestation by cone and seed insects and the possibilities for control.

SILVICULTURE OF PONDEROSA PINE

Natural Establishment of a Ponderosa Pine Forest

Our ponderosa pine research project is continuing intensive study of regeneration establishment. The bumper cone crop in 1958[8] gave opportunity to study the establishment of seedlings in years of near average weather conditions. During the summer of 1963, we observed widespread survival of ponderosa pine seedlings in central Idaho during a period of favorable weather.

Weather, especially during the growing season, usually is a critical factor in survival of reproduction. Annual precipitation, normally 20 to 24 inches, falls mostly in winter and spring. Summer rainfall is often only a trace, temperatures are high, and relative humidities from only 7 to 12 percent are common. This combination of severe climate with shallow, desiccative soils is unfavorable for seedling survival and establishment.

Years with summer weather favorable to seedling survival are rare, but they do occur. The coincidence of a good ponderosa pine cone crop and succeeding favorable weather is even more rare. This combination of favorable conditions was the first since 1941.

The 1962 seedfall was not measured, but observations indicated the crop could be rated fair to good. At least it was good enough to disseminate seeds uniformly through the forests wherever seed trees occurred.

Initial germination in the spring of 1963 was satisfactory but not impressive. The possibility of an unusually successful year for regeneration became evident during July and August when large numbers of seedlings were observed to have survived the normal drought period. Live seedlings grew in many unexpected places, such as dense grass, deep duff and litter (fig. 18), at the base of shrubs, and on old stumps and logs. In most years all of these seedlings would have succumbed to drought or to competition before the end of the summer.

Favorable weather was a major factor responsible for the unusually successful natural regeneration in 1963. The summer of 1963 was moist and cool; thus the drought and insolation that usually are so destructive to seedling establishment were not present.

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[8] Curtis, James D., and Marvin W. Foiles. Ponderosa pine seed dissemination into clearcut groups. Jour. Forestry 59: 766-767. 1961.

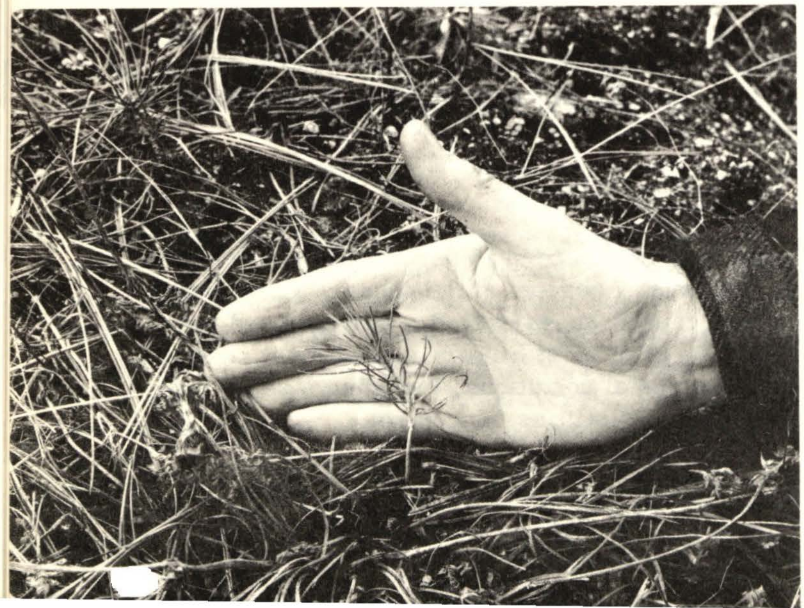

Figure 18.--This ponderosa pine seedling survived in a dense matting of litter and grass and other vegetation.

What will happen to the 1963 crop of ponderosa pine seedlings is not known. Many of them still face severe competition for several years from grass, sedge, brush, and other vegetation. However, these seedlings have been helped through the critical first year by a rare and fortunate coincidence of a moist, cool summer following an adequate seed crop. So many seedlings are alive per acre that it now appears many of them may survive until established and compose an additional age class of the ponderosa pine type. This ecological phenomenon is of more than casual interest to ponderosa pine silviculturists who witnessed it.

SILVICULTURE OF LODGEPOLE PINE

Lodgepole Pine Regeneration in Central Montana

Final results from a long-term study of lodgepole pine regeneration in clear cuttings on the Lewis and Clark National Forest in central Montana are now available. We studied patterns of seed dispersal from a timber edge, period of seed release from standing timber, and the effects of different methods of slash disposal on regeneration density and stocking.

Distances of seed dispersal from overmature uncut timber bordering clear cuttings, observed earlier during a 3-year[9] period immediately following cutting, were confirmed by an additional 4-year study. Lodgepole pine seed do not fall beyond 3 chains (about 200 feet) from a timber edge in quantities sufficient to reproduce a stand. Interior portions of clear cuttings must be restocked primarily from seed released from cones in the logging slash or by artificial methods.

Generally, about two-thirds of all seed released in a year falls between October and June; the remainder is shed from June through September. Although most of this seed comes from nonserotinous cones, published evidence indicates that some seed can come from older serotinous cones that open several years after maturity.

Our records of tree survival show that no significant changes in density or stocking took place after 4 years except on burned seedbeds. Also, between the fourth and tenth years the number of trees per acre increased significantly on both of the burned seedbeds, whereas on other seedbeds no real changes in stocking or density occurred. The following table shows these trends through the course of this study.

Lodgepole pine stocking and density by type of seedbed

Seedbed	Distribution: Stocked milacre quadrats				Density: Trees per acre	
	1950	1951	1954	1960	1954	1960
	Percent				Number	
Burned, piled slash	15	15	28	38	860	1,067
Burned, windrows	24	18	28	40	720	900
Slash, windrows and concentrations	38	28	45	47	1,880	1,867
Forest floor	78	74	80	84	7,010	7,433
Skidroad	95	88	96	94	10,380	10,067
Scarified	83	81	88	93	10,730	10,733
Slash, lopped and scattered	83	76	82	82	9,910	8,800

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[9] Boe, Kenneth N. Regeneration and slash disposal in lodgepole pine clear cuttings. Northwest Sci. 30: 1-11, illus. 1956.

Slash Disposal and Cone Opening

Methods used to regenerate lodgepole pine in central Montana generally produce a superabundance of seedlings. Noncommercial thinnings are needed to provide optimum density; without them the newly regenerated stands soon stagnate. In current practice, slash remains in place during one growing season before disposal; this provides enough time for cones to dry, open, and release the stored seed. Currently used methods for regenerating lodgepole pine need refinements that will result in fewer seedlings per acre without a reduction in stocking.

We thought that if the slash were piled immediately after logging, while still fresh and green, fewer cones would open, less seed would be released, and the potential for overstocking would therefore be lessened. Consequently, we installed a study to determine the effect on regeneration of piling green lodgepole pine slash in clear cuttings as compared with piling slash that had dried through one growing season. Contrary to what we anticipated, two to three times as many lodgepole pine seedlings per acre were established when logging slash was piled green as when it was piled after drying for a growing season.

We wondered what effect height above ground and aspect (north or south) might have on cone opening and release of seed. In a supplementary study we found that serotinous cones placed 1 foot or higher above the ground (fig. 19) did not open, whereas 40 to 83 percent of the cones placed directly on the ground opened on north and south slopes, respectively. An average of some 12 seeds per cone was released from cones that opened; 50 percent of these were sound. This study clearly demonstrated that cones must be on or near the ground to permit opening.

Most cones begin to open when subjected to temperatures above 113° F. We have observed cones on and near the ground beginning to open within 15 minutes after trees had been felled on a hot summer day. When weather conditions are right, only a few days are needed to break the resin bond. Apparently the slash in both treatments, when piled either green or dry, remained in place long enough for the resin bonds to melt on cones that were close enough to the ground.

Although not yet thoroughly tested, the following deductions may explain the anomalous results of the piling experiments.

1. Piling slash after drying through one growing season destroys some seedlings that germinate from seed released either from nonserotinous cones prior to cutting or from serotinous cones that open early enough in the season to permit germination the same year. Piling slash green, however, distributes some cones on the ground where they are more likely to open and where the destructive effects of piling on small seedlings are prevented. Also, most seedlings originating from nonserotinous cones escape possible destruction from piling.

2. Because of the inhibitory effect of slash, it is probable that more seed failed to germinate the first year in the dry slash treatment than in the green slash treatment. Also, exposure of these seeds to destructive agents (rodents, insects, fungi) for an additional year decreased the likelihood of germination the second year.

The problem of how to control density of young lodepole pine stands other than by early thinnings has not yet been solved.

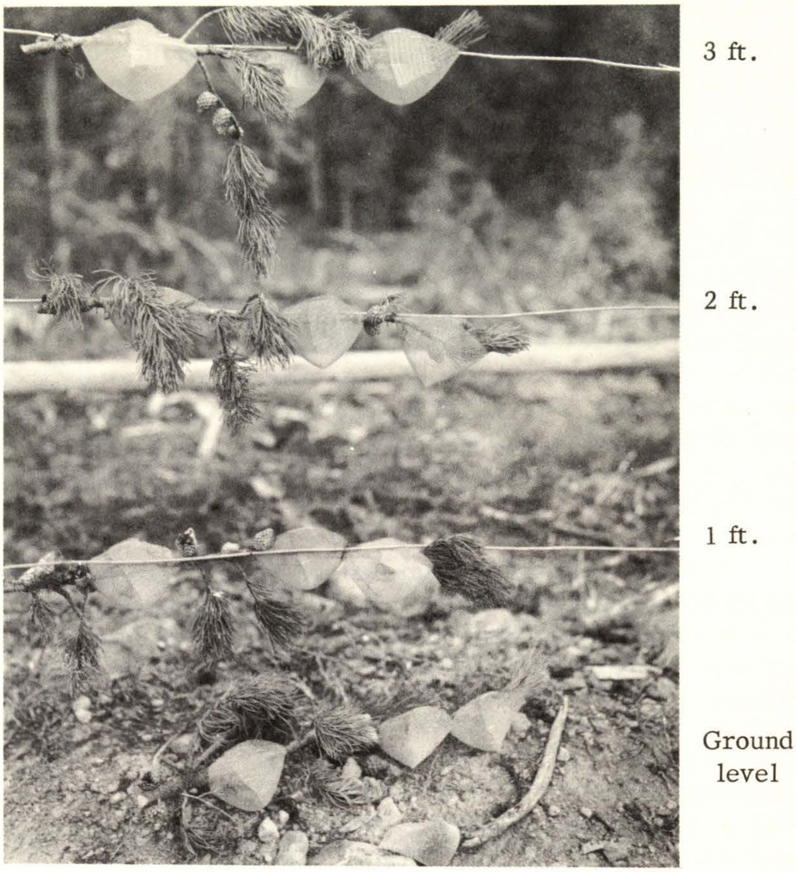

Figure 19.--Branches bearing serotinous cones placed at 1-foot intervals from the ground up. Seeds were caught in the small wire screen baskets.

SILVICULTURE OF WESTERN LARCH AND ENGELMANN SPRUCE

Increasing Success of Direct Seeding

Sowing larch seeds in spots and covering them with soil has consistently doubled germination over that resulting from broadcast-seeding. The first two columns of the following tabulation show germination as a percent of the estimated viable seeds for spot and broadcast-seeding. The last two columns show that germination on the two locations at Coram in 1962 was greater from stratified, spring-sown seeds than from seeds sown the previous fall.

Location	Spot	Broadcast	Fall	Spring
	Percent			
Coram Experimental Forest, 1962	44	22	25	41
Coram Experimental Forest, 1962	48	24	27	42
Coeur d'Alene National Forest, 1963	24	10	32	2

Successful germination from stratified spring-sown larch seeds requires continually moist surface soil. High germination at Coram had also followed a spring sowing in 1960. Rain fell frequently throughout the springs of 1960 and 1962. By contrast, on the Coeur d'Alene National Forest in 1963, no rain fell for 25 days following sowing (May 8) and germination from the spring-sown seeds nearly failed. Fall-sown seeds germinated immediately after snowmelt and were not as severely affected by early dry conditions.

Thinning Western Larch

Two studies in western Montana have given us our first definitive information about thinning western larch. One study is a crop-tree thinning in a 50-year-old stand, with 10 years of data; the other is a light, uniform, low thinning in a 30-year-old stand, with 27-year results. The crop-tree thinnings tested two systems: "D + 4" and "crown." In the D + 4 system, all trees were removed around each crop tree for a radial distance in feet equal to the diameter of the tree in inches, plus 4. In the crown system, a lighter thinning than the D + 4, trees were removed for a radius of 3 to 6 feet from the crown edge, on at least three sides of each crop tree. In the low thinning, the stand was thinned lightly from below to an approximate 7- by 7-foot spacing.

Thinning accelerated diameter growth in all treated stands (see following tabulations). Individual tree analyses showed that thinning response varied by initial tree size and the degree of overstocking (basal area) prior to thinning. The larger dominant trees with well-developed, long crowns responded best, while small-diameter trees with short crowns showed the least response.

Ten-year growth per acre of stand thinned at age 50 (crop trees only)

Treatment	D.b.h. (Inches)	Height (Feet)	Basal area (Sq. ft.)	Volume (Cu. ft.)
D + 4[1]	1.39	10.2	13.0	383
Crown[1]	1.16	9.4	10.9	325
Unthinned	1.03	10.1	8.7	316

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[1] Values are means of two plots.

Twenty-seven-year growth per acre of stand thinned at age 30 (all trees)

Treatment	D.b.h. (Inches)	Height (11 yrs.) (Feet)	Basal area (Sq. ft.)	Volume (Cu. ft.)
Thinned (low thinning)	1.80	7.8	74.8	2,005
Unthinned[1]	1.46	5.2	48.0	1,388

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[1] Values are means of two plots.

Effectiveness of each thinning was evaluated by comparing actual diameter growth with potential growth.[10] Diameter growth of crop trees increased in the D + 4 and crown systems to about three-fourths and two-thirds of growth potential, respectively; it remained at about one-half of potential in the unthinned check. Trees in the plots thinned from below and those in the check plots grew at about one-half and one-third of their potential, respectively (fig. 20). On this basis it appears that the low thinning was too light for maximum effectiveness.

Extreme overstocking adversely affected height growth of larch, but moderate overstocking had no apparent effect. Trees in the heavily overstocked check plots of the low thinning grew only two-thirds as much in height as those in the thinned plot. No differences in height growth could be detected between thinned and unthinned trees in the crop-tree thinnings that were not so heavily overstocked originally.

These two studies demonstrate that the main benefit from thinning is obtained by concentrating the growth on fewer stems. The net result is that in thinned stands larch grows to a larger size at an earlier age than it does in unthinned stands.

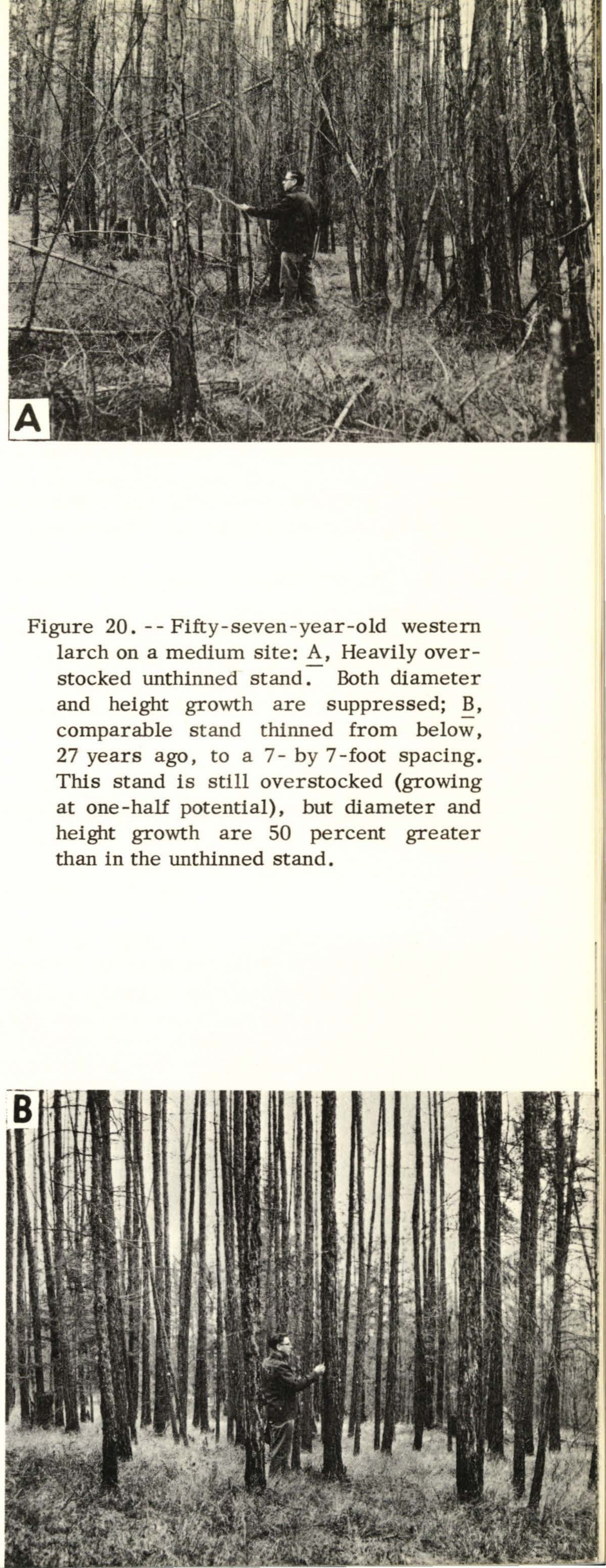

Figure 20. -- Fifty-seven-year-old western larch on a medium site: A, Heavily overstocked unthinned stand. Both diameter and height growth are suppressed; B, comparable stand thinned from below, 27 years ago, to a 7- by 7-foot spacing. This stand is still overstocked (growing at one-half potential), but diameter and height growth are 50 percent greater than in the unthinned stand.

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[10] Potential growth is based on larch normal-yield data with adjustments for proper site, age, and optimum stocking throughout the life of the stand.

MENSURATION

Inventory Methods

Timber management, as it becomes more intensive, requires better information about the trees to be managed. Improved inventory methods to meet these demands can be designed if we have available rapid, accurate procedures for comparing the performance characteristics of alternative rules for inventory sampling. To meet this need, we have prepared a means of estimating many of the statistical parameters that describe the sampling characteristics of a proposed rule. Maps of actual forest stands are sampled by means of a digital computer program according to the logic of the sampling rule being tested.

The performance of the sampling rules is summarized by:

1. The means, variances, and correlations of estimates of numbers of trees and basal areas per acre of crop trees and excess trees.

2. The skewness, kurtosis, and autocorrelation of estimates of basal area per acre.

3. A two-way table of the number of sample centers falling in stocking condition classes according to number of crop and excess trees.

4. A frequency distribution of the number of samples that included a particular tree as a crop tree.

Study of these empirical results provides a means of testing the adequacy of new sampling rules for obtaining meaningful, efficient data for effective timber management.

Growth of Forest Trees and Stands

Prediction of future forest growth is basic to forest management. During 1963, a procedure for making detailed projections of forest stands based on the estimates of diameter growth, mortality, and timber cut was adapted to conditions characteristic of western forests. The procedure, which requires the use of a high-speed digital computer, was originally developed at the Southeastern Forest Experiment Station. Working with the Pacific Northwest Forest and Range Experiment Station, we modified the basic procedure to provide controls on the predicted per acre values of basal area and basal area increment. This machine program was widely used in the 1963 compilation of National Forest survey statistics.

To assess the total effect of weather changes on forest growth, we developed a method of calculating daily moisture stress which permitted a realistic recognition of the shape of soil-moisture depletion curves on specific soil types. This procedure was determined in cooperation with Professor Robert Zahner of the University of Michigan following basic procedures developed by Thornthwaite, but modified to better represent the wetting process following drought. Correlations of growth with weather using the calculated moisture stress in addition to temperatures and precipitation were tested for basal area growth of western white pine in northern Idaho and height growth of red pine in Michigan. The calculation of daily moisture stress, although functionally determined by temperature and precipitation, did provide additional information useful in establishing a prediction of growth response to weather variation.

WATERSHED MANAGEMENT

Maintenance of soil stability under varied land uses is prerequisite to continuing productivity and acceptable functioning of hydrologic processes on forest and range watersheds. Our program includes numerous studies in watershed protection, watershed rehabilitation, and water yield improvement. This year we have centered attention on two closely related activities in which preservation of soil stability is paramount, namely, timber harvesting operations and livestock grazing.

GOOD LOGGING PRACTICES REDUCE SEDIMENTATION IN CENTRAL IDAHO

More than 11 years ago the best known timber harvesting and soil-conserving practices of that day were applied to a group of small watersheds situated on moderate to steeply sloping topography in the ponderosa pine-granitic soil zone in central Idaho. The long-term watershed management objective of the study was to evaluate the effects of these practices on erosion and sedimentation. In 1963 the study was completed and the results have been summarized to show sediment origin and rate of movement to and down stream channels.

The logging operation produced two forms of sediment flows: (1) surface sediment en route rom the source of erosion through the undisturbed forest floor (fig. 21), and (2) channel sedinent, made up of surface sediment flows and material eroded directly from a haul road or kidtrail that intersected a watercourse. The amount of surface sediment reaching channels in ifferent watersheds varied considerably. A few watersheds had channel sediment trapped ownstream in settling ponds, but the majority did not.

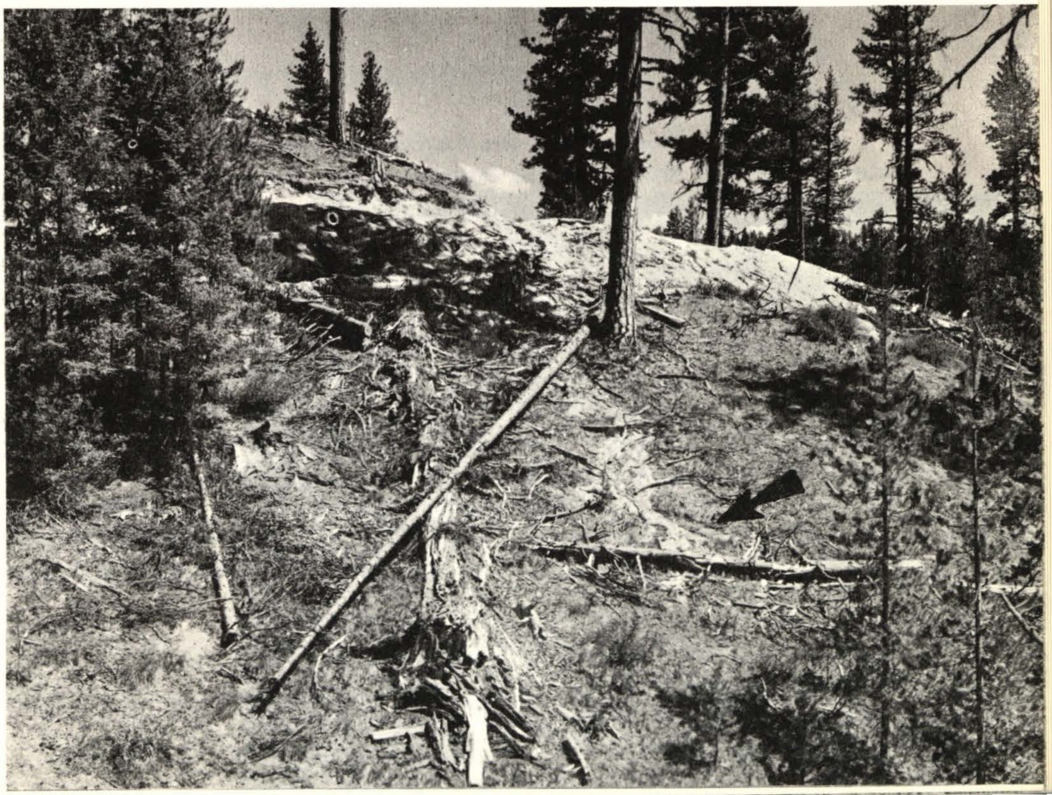


Figure 21.--Surface sediment en route from logging haul road. Arrow locates front of flow.

We found no relation between areal extent of logging disturbance and frequency of surface sediment flows that reached a channel. Some watersheds with relatively large areas (10 to 12 percent) bared by skidding and road construction produced little or no channel sediment. By contrast, one watershed with only 2 percent of its area disturbed had considerable surface sediment reach its channel. We concluded that variations in silvicultural and logging practices in this study had little or no bearing on volume of sediment reaching a watercourse.

Haul road disturbance produced surface sediment reaching a channel more often than skidtrail disturbance. The hydrologic reasons for this are sound: roads frequently intercept and concentrate seepage flow, and they usually have lower infiltration rates than skidtrails. Thus, they have a greater potential for producing overland flow that causes erosion. But, in this study, a large acreage of roads in a given watershed did not necessarily imply that a great number of surface sediment flows reached the watershed's channel. Instead, the nearness of a road to a stream channel, or the width of a protective strip between the road and stream channel proved to be the key factor. A related study has shown that narrow protective strips containing many surface obstructions such as stumps, standing trees, exposed rock, dense brush, or logging slash were equally as effective as wide strips containing few surface obstructions.

Movement of sediment downstream in ephemeral watercourses was surprisingly slow. Such natural obstacles as brush and fallen snags retarded forward progress, but, more often, volume and velocity of streamflow were too low to transport the material easily. Conversely, in perennial streams sediment moved progressively downward, as evidenced by new material being deposited continuously in settling ponds. This implies that road construction and logging are more hazardous in relation to sedimentation if done adjacent to a perennial stream.

Despite the sediment flows that moved from roads during early years after logging, the average yearly yield of channel sediment measured downstream in settling ponds was considered very low for the logged study area as a whole. Credit for this low sedimentation rate can be given primarily to advance planning that provided for adequate protective strips on most watersheds, close supervision of logging, the intensive soil-conserving measures that were applied promptly after log hauling was completed, and the small number of perennial streams.

IMPROVING STABILITY OF ROAD FILLS

Preventing erosion and reestablishing vegetation on road fill slopes composed of soil material derived from granite become more critical and difficult as logging roads traverse steeper terrain. Where slope gradients exceed 60 percent, roadbeds must be partially or entirely "benched." This requires deep cuts, and consequently produces a surplus of road material. The surplus material is usually side cast and comes to rest in long unstable fills that may extend for 100 feet or more down a ravine on the incurve section of a road. These fills are generally shorter below the outcurve section.

This year two road drainage measures--insloping and outsloping the roadbed surfaces--were evaluated on a secondary logging road in central Idaho that (1) had been built for less than 6 months, (2) traversed mountain slopes generally exceeding 60-percent gradient, and (3) usually left exposed a high cut bank of granite rock overlain by very shallow soil. Shortly after these drainage measures were installed, the road was subjected to an unusually long rainfall that totaled almost 10 inches. Damage to the road fill from erosion and slumping was substantial.

Observations indicated that insloping a roadbed of the type described above, before it is subjected to a long-duration rainstorm, prevents erosion more effectively than outsloping (fig. 22). The inslope should be designed to lead storm runoff away from the long fill on the incurve of the road to a selected disposal area. Where culverts are used in major ravines, they should be located on the original water grade so that they do not discharge on the fill of the incurve but drain into the original channel. Earthen cross drains should be located to discharge their flows on the outcurve of the road. Below the outcurve, the undisturbed protective strip will absorb some road drainage and retard sediment flows before they reach a ravine or stream. Even with the best design of road drainage, some erosion damage may be expected following very heavy rainfall.

For permanent protection vegetation must be reestablished on fill slopes as rapidly as possible. Attempts to revegetate often give erratic results because the hardened, compacted, crusted surfaces of steep fills do not retain sufficient broadcast seed. Model "road fill slopes" were set up in the laboratory to test several treatments of soil surface designed to arrest downward movement of broadcast seed. The records of relative numbers of seeds retained on laboratory model slopes are probably fair indices for judging the merits of each treatment; but we cannot certainly postulate what might happen under field conditions.

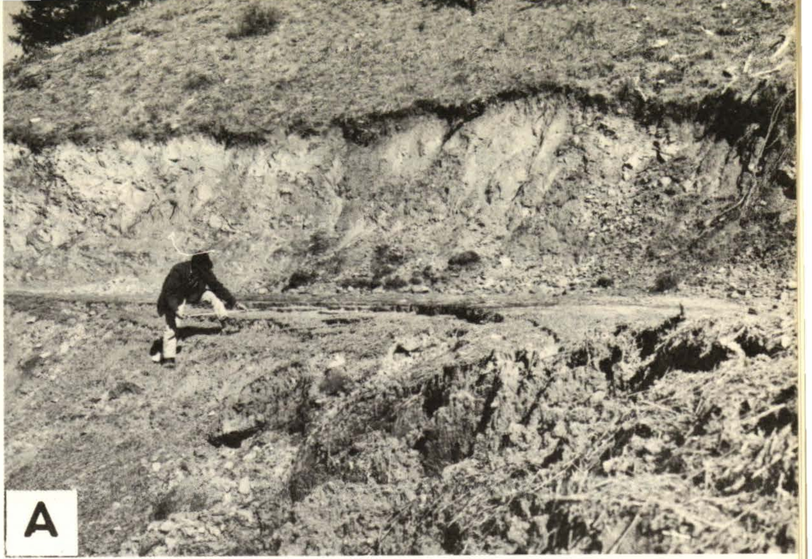
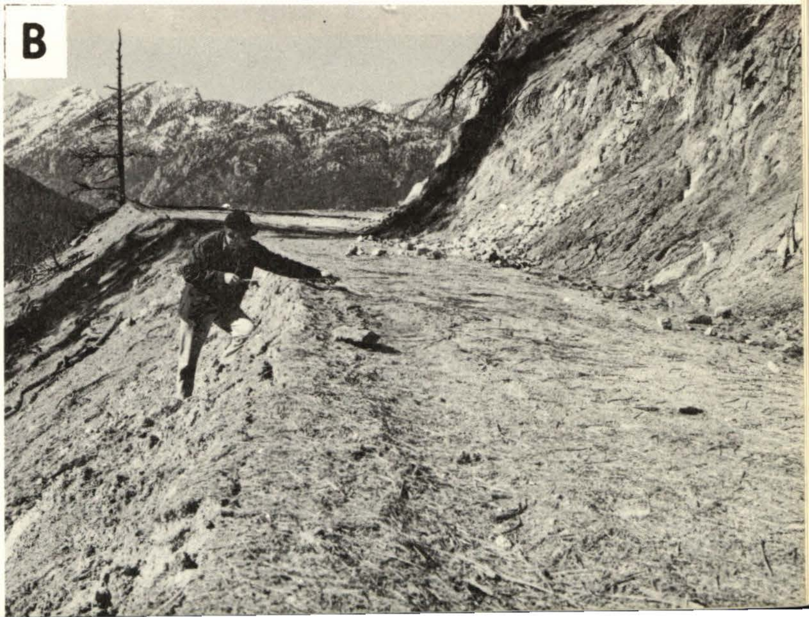


Figure 22.--A, Outsloped section of road following severe rainstorm. Note slumping of fill; B, insloped section of road with berm. Damage to fill bank was not as great as on outsloped road.



These comments and recommendations follow from examining the data obtained from this laboratory study:

1. Hard, round seed of cereal type and yellow sweetclover are more apt to roll and slide downhill on road fills than the elongated, flat seed of intermediate wheatgrass and smooth bromegrass.

2. Applying seed to a road fill pockmarked with shallow holes, or to a wet road fill, or applying wet seeds on a dry surface increases likelihood of retention after they fall. Punching holes is a better treatment on dry, crusted surfaces than on wet, soft road fills. The relative success of these three treatments is more likely if hard, round seed are included in the mixture.

3. Seeding upon a paper mulch or after an unchopped hay mulch was applied proved to be the best method tested for reducing the downhill movement of seed. However, substantial numbers of seeds are trapped on the leaves and stems of the hay before they reach the soil surface.

CONTROLLING EROSION FROM SKIDTRAILS

Bared skidtrails on sloping terrain are an important source of sediment. A study completed this year shows how skidtrails may be treated to control excessive overland flow and erosion.

Many soils in central Idaho are derived from granite or basalt. Skidtrails on granitic soils are more susceptible to erosion than those located on basaltic soils; but, regardless of parent material, skidtrails in ravine bottoms are much more susceptible to erosion than those on sidehills.

To control erosion from skidtrails, structures (fig. 23) should divert water from the skidtrail onto undisturbed forest floor; this practice is more effective than merely retarding the flow of water. Optimum distance between structures depends on many variables, including parent material, percent slope, and topographic location of the skidtrail. Recommended spacings for water-diverting structures are:

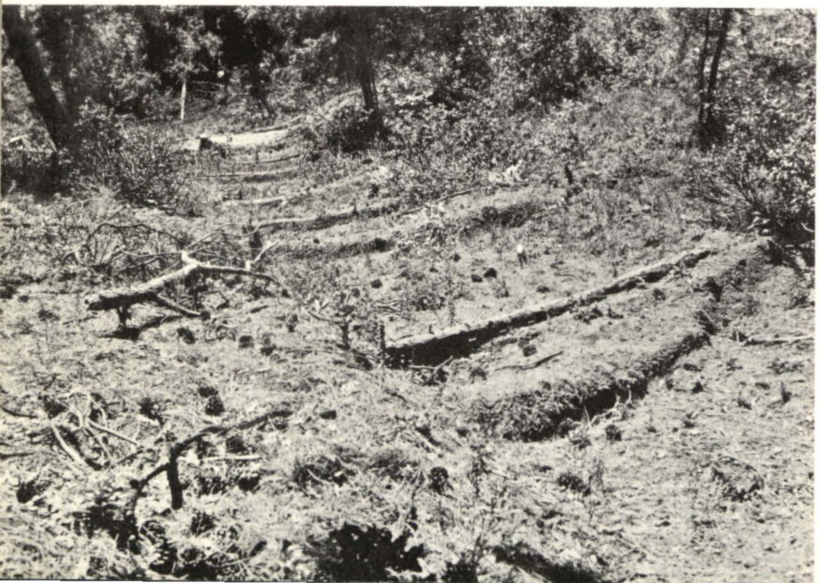


Figure 23.--Downhill view of skidtrail treated by building log water bars at 10-foot intervals. The bars are angled to divert water onto the undisturbed forest floor.

	Spacing on--			
	Soil from granite		Soil from basalt	
Slope (percent)	Sidehills	Ravines	Sidehills	Ravines
	Feet			
10	65	50	90	80
30	40	25	60	50
50	20	15	40	35
70	10	10	15	15

EFFECTS OF WATERSHED TREATMENTS ON INFILTRATION AND SOIL STABILITY

Soil on mountain range watersheds where the vegetation has been depleted or destroyed is highly susceptible to erosion by raindrop impact and overland flow during summer rainstorms. Control of overland flow and erosion has been achieved on some of these rangelands by seeding grasses to restore vegetation. Other areas still fail to respond to this control measure.

Our past research has established certain important relations between plant cover, soil properties, overland flow, and erosion on several kinds of range. Recent studies have attempted to define these relations more precisely so that we can develop better criteria for effective watershed protection. We are also concerned with learning more about how overland flow and erosion and plant cover and soil properties are affected by plant cover restoration measures and grazing use.

A 4-year study recently completed on a cattle grazing unit of a grass-forb subalpine range in Manti Canyon in central Utah yielded considerable useful information about the effects of disking, seeding, and grazing on plant cover, soil properties, infiltration, and soil stability. It demonstrated that the infiltration capacity of infiltrometer plots during a simulated 50-minute rainfall is influenced primarily by bulk density and noncapillary porosity of the surface 4 inches of soil and, secondarily, by the density of protective cover afforded by plants, litter, and stone. Figure 24A shows that the amount of water retained by plots decreases as the soil bulk density increases and as the noncapillary soil porosity decreases. The effect of differences in total ground cover on water retention, shown in figure 24A, is presented in figure 24B. The study also showed that soil stability improves as the cover density increases and as soil bulk density decreases (fig. 24C).

The combination of disking, as a method of site preparation, and seeding of grasses affected plant cover and soil properties in the Manti Canyon study as follows:

1. Density of protective cover decreased.

2. Organic matter in the surface 2 inches of soil decreased.

3. Palatable grasses increased significantly and unpalatable forbs decreased.

4. Capillary porosity decreased, but noncapillary porosity increased on highly compacted sites.

5. Total porosity decreased, but soil bulk density increased on sites in good condition.

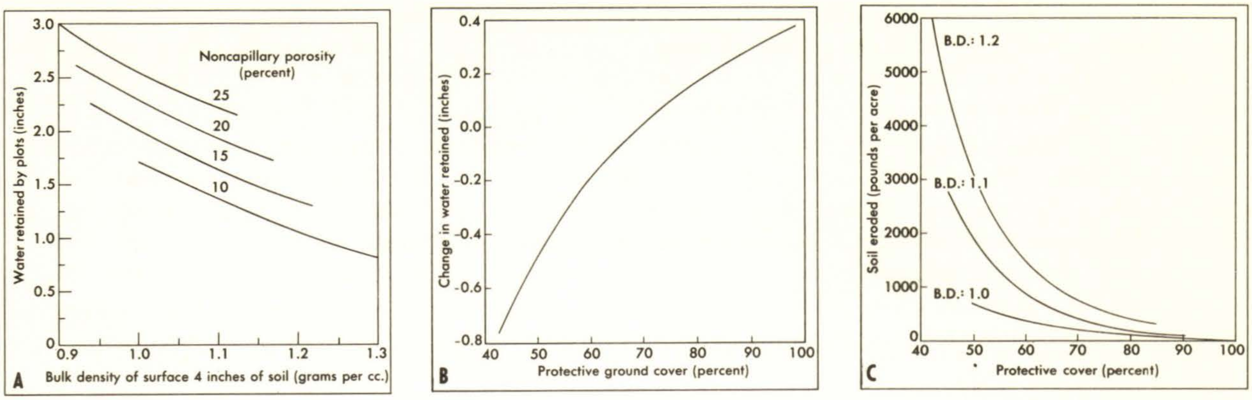


Figure 24.--A, Relation of water retained by infiltrometer plots (during a 50-minute simulated rain) to bulk density and noncapillary porosity of surface 4 inches of soil when 70 percent of the soil surface is protected from direct raindrop impact; B, relation of protective ground cover to amount of water retained by plots; C, relation of amount of soil eroded from plots (during a 50-minute simulated rain) to bulk density (B.D.) of the surface 4 inches of soil and protective cover.

Disking and seeding to grasses increased the amount of water retained and decreased the amount of soil eroded where the plant cover was initially badly depleted and the soil highly compacted. These treatments decreased infiltration and increased the amount of soil eroded where both the plant cover and soil were initially in good condition.

The main effects of moderate late summer grazing by cattle on plant cover and soil properties were:

1. Live plant cover and litter density decreased.

2. Noncapillary porosity decreased, but capillary porosity increased.

This grazing intensity reduced infiltration on the infiltrometer plots from an average of 2.28 inches to an average of 1.71 inches as measured during 50 minutes of simulated rainfall. It also increased the amounts of soil eroded from these plots from an average of 313 pounds per acre to an average of 913 pounds per acre during the same period.

Reasonable approximations of conditions required for effective watershed protection on similar range sites in central Utah can be derived from this study:

1. Bulk density of the surface 4 inches of soil less than 0.97 gram per cubic centimeter.

2. Total protective cover at least 85 percent.

3. Noncapillary porosity of the surface 4 inches of soil at least 22 percent.

Any one of these conditions can be considered as a single protection requirement. However, the protection requirement can be somewhat less stringent if all three site factors are considered. Figures 24A and 24B may be used to estimate the combined values of soil bulk density, noncapillary porosity, and total protective cover required to obtain a given amount of retention. For example, figure 24A shows that if bulk density is 1.00 gram per cubic centimeter and noncapillary soil porosity is 15 percent, 50-minute water retention is only 2.0 inches on sites where the total cover is 70 percent. Figure 24B shows that retention is 0.15 inch greater (i.e., 2.15 inches) if the total protective cover is 80 percent.

Where soil bulk densities are too high for effective control of overland flow, soil erosion can still be minimized by maintaining a dense protective cover (as shown in figure 24C). A dense plant and litter cover is further desirable for its beneficial effect in decreasing soil bulk density and increasing noncapillary soil porosity.

In another study, the effects of disking and seeding to grass were also evaluated in the subalpine zone of Pleasant Creek, in central Utah, as part of a restoration program[11] on that watershed, portions of which had been damaged severely and were flood-source areas. Infiltration capacity, soil stability, the amount of plant and litter cover, and soil bulk density were measured immediately before damaged areas were treated by disking and seeding, then 3 years after seeding, and 6 years after seeding.

Soil bulk density was lower on all seeded sites 6 years after treatment, and the greatest decreases occurred on those sites that had been most compacted initially. Changes in cover density following treatment varied, depending on the initial state of depletion and the potential site productivity. Plant and litter cover on depleted sites, particularly those on the more productive soils, responded favorably to seeding, but a reduction in total cover occurred on those sites that supported good plant and litter cover before treatment.

Infiltration capacity, like vegetation, improved on the more depleted sites, but decreased on sites that were initially in satisfactory condition. The net effect was a significant increase in average infiltration capacity and a reduction in variability of infiltration capacity from site to site.

The immediate effect of disking on soil stability was detrimental. The soil was less stable 3 years after treatment than it had been before treatment. However, 6 years after treatment the soil on most sites had regained its stability and on those sites where cover improvement was greatest the soil was much more stable than it had been before treatment.

These results suggest that the best response to disking and seeding can be obtained where pretreatment cover is badly depleted but where potential productivity and inherent soil stability are reasonably high. Areas already in fair to good condition may respond adversely to cultivation. Where plant and litter cover are adequate, disking out all the plants (many of which were years in developing) and attempting to establish a different group of plants can reduce protective cover and soil stability for an undetermined period. Disking and seeding to grass should not be employed indiscriminately as a watershed restorative treatment but should be restricted to those areas where low initial cover, compacted soil, and high potential productivity promise favorable response to such treatment.

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[11] Authorized by Public Law 566.

PUBLICATIONS

BARNES, BURTON V., and R. T. BINGHAM. Flower induction and stimulation in western white pine. Res~~earch~~ Pap~~er~~ INT-2, 10 pp.
U.S. Forest Serv. Intermountain Forest and Range Exp. Sta.

Describes four experiments designed to discover means of inducing strobilus formation in young seedlings and grafts of western white pine. Not one of the methods attempted was successful in markedly inducing or stimulating strobilus production.

BARNES, BURTON V., and R. T. BINGHAM. Cultural treatments stimulate growth of western white pine seedlings. Research Note INT-3, 8 pp., illus.

Describes an experiment to determine effectiveness of cultural treatments (cultivating, fertilizing, and watering in all possible combinations) in stimulating growth rate and inducing strobilus formation. Strobilus production was negligible, but striking differences in total height and diameter growth were attributed to the treatments.

BARROWS, J. S. Forest fire science. Naturalist 14(4): 18-25, illus. (No reprints)

Describes the forest fire research projects being carried on at the Northern Forest Fire Laboratory, Missoula, Montana, and their relation to the national forestry effort.

BARROWS, J. S. 1962 status and activities of forest fire research laboratories. West. For. and Conserv. Assoc., West. For. Fire Res. Council Proc., pp. 1-4.

Reviews status and activities of research projects being carried on at the three forest fire research laboratories of the U.S. Forest Service at Macon, Georgia; Missoula, Montana; and Riverside, California.

BARROWS, J. S. Fire weather aspects of research at the Northern Forest Fire Laboratory. 1963 West. Fire Weather Met. Conf., Portland, Oregon. 15 pp. (No reprints)

Discusses the relationship of weather aspects to the fire research projects being carried on at the Northern Forest Fire Laboratory, Missoula, Montana.

BETHLAHMY, NEDAVIA. Rapid calibration of watersheds for hydrologic studies. I.A.S.H. Bull. VIII: 38-42. (No reprints)

Streamflow data from a number of individual storms rather than the total data for the year provide a greater number of observations for calibrating watersheds. Accuracy of prediction is high and the time required for calibration is shortened.

BINGHAM, R. T. New developments in breeding western white pine. I. Breeding for blister rust resistance. Forest Genetics Workshop Proc., South. Forest Tree Improvement Com. Sponsored Pub. 22: 69-70.

Recent developments under the long-range program for breeding blister rust resistant western white pine are reported. Establishment of seed orchards to produce 50-percent resistant F_2 seed by 1970 appears to be feasible.

BINGHAM, R. T., J. W. HANOVER, (H. J. HARTMAN, and Q. W. LARSON).* Western white pine experimental seed orchard established. Jour. Forestry 61: 300-301, illus.

Management practices for western white pine seed orchards are being analyzed on a 17-acre orchard established in 1960 on the Kaniksu National Forest at Sandpoint, Idaho. Information gained here will apply to the operation of 100 acres of grafted seed orchards proposed for production of relatively resistant western white pine stock.

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* Authors whose names are in parentheses are not members of the Intermountain Station staff.

CHOATE, GROVER A. The forests of Wyoming. Resource Bulletin INT-2. 40+ pp., illus.

Comprehensively describes the forest resource of the State and shows opportunities for its further development; indicates difficulties associated with development.

(DUFFIELD, J. W.), and R. T. BINGHAM. Forest genetics and its application by the small woodland owners. *IN*: Woodland Handbook for the Pacific Northwest, pp. 286-288. Fed. Coop. Ext. Serv. Oregon State Univ., Corvallis, Ore., 422 pp. (No reprints)

Provenance, heritability, plus tree seed orchard and fertilization studies point the way toward practical steps that the small woodland manager may take in improving seed used for reforestation. It suggests that the manager develop his own "local" seed supply, that he insist that genetic identity of his seed and nursery stock be maintained, and that he give consideration to genetics in his timber harvesting practices.

FARRENKOPF, THOMAS O. Montana Christmas tree exports decline for third straight year. Research Note INT-7, 4 pp., illus.

Records of shipments by rail and truck of Montana Christmas trees show a consistent decline during the past 3 years. Severe attacks by disease and insects seriously damaged the appearance of harvestable trees and thus reduced the cut.

FERGUSON, ROBERT B., MALCOLM M. FURNISS, and JOSEPH V. BASILE. Insects destructive to bitterbrush flowers and seeds in southwestern Idaho. Jour. Econ. Ent. 56: 459-462, illus.

Weekly examinations and dissections of bitterbrush flowers and seeds revealed damage by several insects. The thrips *Frankliniella occidentalis* damaged buds and flowers. After seed formation, damage was caused by a gall midge, a gelechiid, and the Say stink bug.

FRISCHKNECHT, NEIL C. Contrasting effects of big sagebrush and rubber rabbitbrush on production of crested wheatgrass. Jour. Range Mangt. 16: 70-74, illus.

Yields of grass around isolated big sagebrush (*Artemisia tridentata*) plants were depressed for a distance proportional to size of the brush. Comparable plants of rubber rabbitbrush (*Chrysothamnus nauseosus*) did not depress grass yields. Differences in root systems and growth habits are cited as accounting for contrasting effects.

FUQUAY, D. M. Recent trends in meteorology related to fire weather. West. For. and Conserv. Assoc., West. For. Fire Res. Council Proc., pp. 20-22, 1961.** (No reprints)

Reviews recent trends in meteorology, such as weather satellites, manpower, research facilities and programs, and their possible effects on fire weather forecasting.

HANOVER, JAMES W. Geographic variation in ponderosa pine leader growth. Forest Sci. 9: 86-95, illus.

Growth of the short apices of 91 trees in a 45-year-old ponderosa pine provenance test was measured periodically with a transit. The 19 races in the test showed phenological, morphological, or physiological variation in six characteristics: date of beginning growth in the spring, date of ending growth, total seasonal elongation, duration of growth, length of dormant terminal bud, and rapidity of growth.

HANOVER, JAMES W. New developments in breeding western white pine. II. Biochemistry of rust resistance. Forest Genetics Workshop Proc., South. Forest Tree Improvement Com. Sponsored Pub. 22: 76-78.

Biochemical analyses for free sugars, amino acids, protein hydrolysates, organic acids, chlorophyll, B-carotene, and phosphorylated compounds, and analyses for dry-matter, pH, and ash, have failed to show associations with blister rust resistance. Preliminary information indicates association of a phenolic compound with resistance, but much additional study will be required to verify the association.

** Not previously included in 1962 report of Station publications.

HANOVER, JAMES W., and BURTON V. BARNES. Heritability of height growth in year-old western white pine. Forest Genetics Workshop Proc., South. Forest Tree Improvement Com. Sponsored Pub. 22: 71-76.

An analysis for computing heritability based on a modified diallel cross is described in detail using total height and epicotyl length of 1-year-old western white pine seedlings.

HARDY, CHARLES E., and (JAMES W. FRANKS). Forest fires in Alaska. Research Paper INT-5, 163 pp., illus.

Comprehensively describes and analyzes the problems of forest fire causes, detection, and control peculiar to our 49th State. Relates these problems to resource values at stake and discusses pertinence of geography, climate, and fuels to fire danger and fire control operations. Includes extensive records and statistical information.

HAUPT, H. F., and W. J. KIDD, Jr. Laboratory methods for determining the downward movement of seed on road fills. Research Note INT-2, 7 pp., illus.

Seeding upon a mulch, "pockmarking" the soil surface, wetting the soil, and spreading wetted seed, improve retention of seed in place on crusted road fills.

HAUPT, H. F., (H. C. RICKARD, and L. E. FINN). Effect of severe rainstorms on insloped and outsloped roads. Re~~search~~ Note INT-1, 8 pp., illus.
U.S. Forest Serv. Intermountain Forest and Range Exp. Sta.

Insloping a newly constructed roadbed on steep slopes in an area of granitic soil is desirable for preventing erosion and damage to the road when it is subjected to heavy rainfall.

(HAWKSWORTH, FRANK G.), and DONALD P. GRAHAM. Dwarfmistletoes on spruce in the western United States. Northwest Sci. 37: 31-38, illus.

The western spruce dwarfmistletoe, Arceuthobium campylopodum f. microcarpum, is known only from Arizona and New Mexico. Other dwarfmistletoes (A. americanum, A. campylopodum f. laricis, A. campylopodum f. tsugensis, A. douglasii, and possibly A. campylopodum f. cyanocarpum) may sometimes attack western spruces and have erroneously been reported as A. campylopodum f. microcarpum elsewhere in the West.

(HAWKSWORTH, FRANK G.), and DONALD P. GRAHAM. Spread and intensification of dwarfmistletoe in lodgepole pine reproduction. Jour. Forestry 61: 587-591, illus. (No reprints)

Studies of 79 plots in Colorado, Montana, and Wyoming showed that infection in young stands adjacent to infected mature stands varied from 3 percent in 10-year-old stands to 32 percent in 25-year-old stands. Suggestions for control of dwarfmistletoe in lodgepole pine reproduction are given.

HIRSCH, S. N. Applications of remote sensing to forest fire detection and suppression. Univ. Mich., Inst. Sci. and Tech. The Second Symposium on Remote Sensing of Environment Proc., 1962, pp. 295-308, illus.

Describes the problems in fire detection and surveillance and offers some solutions in infrared and sferics. The research under Project Fire Scan is discussed.

(HULL, A. C., Jr.), RALPH C. HOLMGREN, (W. H. BERRY, and JOE A. WAGNER). Pellet seeding on western rangelands. U.S. Dept. Agr. Misc. Pub. 922, 34+ pp., illus.

Critical evaluation of all available documented information leads to the conclusion that pellet seeding cannot be recommended for revegetating western rangelands.

(HUNT, WILLIAM A.). Some engineering considerations of a wood chip pipeline. Forest Prod. Jour. 13: 365-367, illus. (No reprints)

Presents the need for basic research into hydraulics of transporting wood chips by pipeline, and shows economic importance of design data on pipe friction, concentration of solids, and pumping equipment.

INTERMOUNTAIN FOREST AND RANGE EXPERIMENT STATION. Annual report 1962. 55+ pp., illus.

Reports year's activities of the Station.

KIDD, W. J., Jr. Soil erosion control structures on skidtrails. Res~~earch~~ Pap~~er~~ INT-1, 8 pp., illus.
U.S. Forest Serv. Intermountain Forest And Range Exp. Sta.

Reports results of different erosion control structures on skidtrails on soils derived from granite and basalt. Recommends optimum spacing according to soils.

LAYCOCK, WILLIAM A. An annotated bibliography of range management publications from the U.S. Sheep Experiment Station. Wyoming Range Mangt. No. 175, 10 pp. (No reprints)

Briefly characterizes 55 publications on range research conducted wholly or partially at the U.S. Sheep Experiment Station, near Dubois, Idaho, by the Intermountain Forest and Range Experiment Station in cooperation with the Animal Husbandry Research Division of the Agricultural Research Service and the University of Idaho.

LEAPHART, CHARLES D. Armillaria root rot. U.S. Dept. Agr., Forest Serv., Forest Pest Leaflet 78, 8 pp., illus.

Characteristics of the root disease caused by Armillaria mellea in conifers and hardwoods and the methods of its spread are described. Types of damage and methods for its control are outlined.

LEAPHART, CHARLES D. Dwarfmistletoes: A silvicultural challenge. Jour. Forest~~ry~~ 61: 40-46, illus. (No reprints)

Dwarfmistletoes, one of the most serious diseases in conifer stands of the western United States, can be controlled at certain periods in the rotation of a stand through silvicultural procedures. Important publications about dwarfmistletoes and their control, research needed to improve existing guides, and suggested steps to achieve adequate control programs are discussed.

LLOYD, MERLE G. Recording dew gage. Fire Control Notes 24: 42-44, illus. (No reprints)

Describes the calibration and operation of an instrument for recording the amount and time of dew or rain over a 7-day period.

LOWERY, DAVID P., and (E. F. RASMUSSEN). Accelerated drying of lodgepole pine and western larch poles. Forest Prod. Jour. 13: 221-226, illus.

Study of accelerated drying indicates that lodgepole pine and western larch poles can be dried at relatively high temperatures (180° to 200° F.) in 2 to 3 days and can be treated satisfactorily with preservative. Describes the drying chamber and presents data obtained during and after the drying process. Reports results of strength tests on specimens obtained from the dried poles.

LYON, L. JACK. Administration of natural resources research: some lessons from industrial research. Amer. Inst. Biol. Sci. and Colorado Dept. Game and Fish. 62+ pp., illus.

Discusses elements of successful research administration gleaned from literature and correspondence with research directors in more than 50 organizations.

MERRIAM, ROBERT A., and OTIS L. COPELAND. Comments on neutron soil moisture probe efficiency and sensitivity. Soil Sci. Soc. Amer. Proc. 27: 106-107, illus.

Discusses considerations of cost, radiation hazard, durability of components, service, and compatibility of elements as related to the acquisition of neutron soil moisture meters.

MERRIAM, ROBERT A., and OTIS L. COPELAND. Brief concluding comments about neutron probe sensitivity. Soil Sci. Soc. Amer. Proc. 27: 604.

Sensitivity or calibration curve slope is one of the important factors to be considered in use of neutron soil moisture probes.

(MIELKE, J. L.). Comandra blister rust. IN: Internationally Dangerous Forest Tree Diseases. U.S. Dept. Agr. Misc. Pub. 939: 92-93. (No reprints)

Concisely describes the symptoms and life cycle of comandra blister rust and lists its hosts.

MOESSNER, KARL E. A test of aerial photo classifications in forest management-volume inventories. Research Paper INT-3, 16 pp.

This study compares several photo and map stratification schemes. In estimating volume, photo-volume classes offer the best means of stratification and provide other data useful in management.

MOESSNER, KARL E. Why not use blueprints? Research Note INT-4, 2 pp., illus.

Aerial photos and mosaics made from them are used satisfactorily as map substitutes on many field jobs. Blueprints from photographic negatives have proved to be equally useful and are much cheaper than the usual black-and-white prints.

MOESSNER, KARL E. Accuracy of ground point location from aerial photographs. Research Note INT-5, 4 pp., illus.

A recent study using 84 points located with 1:16,000-scale aerial photos indicated the average error in ground location to be only about 30 feet on lines averaging 500 feet in length. Errors averaged 17 feet in distance and 19 feet in direction, or slightly more than the width of a dull pencil line on the scale photos used.

MOESSNER, KARL E. Composite aerial volume tables for conifer stands in the Mountain States. Research Note INT-6, 4 pp.

Presents new composite aerial volume tables for conifer stands based on data from 460 Forest Survey field plots. The two tables list average board-foot and cubic-foot volumes per acre by total height and crown cover class, and can be used for stratification by photo-volume class. Includes regression formulae and measures of accuracy.

MOESSNER, KARL E. Estimating depth of small mountain lakes by photo measurement techniques. Photogrammetric Engin. 29: 580-588, illus.

A new technique based on photogrammetric measurement of shore slopes uses medium scale resource photographs already available. Estimates of the shallow area on 21 lakes were not significantly different from areas measured by field soundings that cost 10 times as much.

PACKER, PAUL E. Soil stability requirements for the Gallatin elk winter range. Jour. Wildlife Mangt. 27: 401-410, illus.

Reports results of seeding and protection on soil stability on the Gallatin elk winter range. Recommends soil and vegetation requirements to restore stability to rangelands.

(PECK, EUGENE L.), and DALE J. PFANKUCH. Evaporation rates in mountainous terrain. I.A.S.H. Pub. 62: 267-278, illus.

Evaporation rates from 13 Weather Bureau "Class A" evaporation stations in the Wasatch Mountains vary appreciably in relation to elevation, exposure, temperature, and wind movement.

PETERSON, ROGER S. Effects of broom rusts on spruce and fir. Research Paper INT-7, 10 pp., illus.

Yellow witches'-brooms caused by rust fungi are associated with several types of damage to spruce and true firs. Although the occurrence of spruce broom rust is correlated significantly with reduction of both diameter and height growth rates in infected trees, fir broom rust appears to have little effect on growth rates.

PFISTER, ROBERT D., and (PHIL C. WOOLWINE). Insect damage in grand fir cones. Res~~earch~~ Note INT-8, 3 ~~p~~p.
U.S. Forest Serv. Intermountain Forest And Range Exp. Sta.

Depredation by six genera of cone and seed insects on grand fir caused loss estimated at more than 15 percent of the seed crop in this limited study in a drainage in northern Idaho.

PISSOT, HENRY J., and (HAROLD E. HANSON). The forest resource of western Montana. Resource Bulletin INT-1, 39+ pp., illus.

The most recent forest inventory of Montana west of the Continental Divide indicates a present timber volume of 73.5 billion board feet on the 10.5 million acres of commercial forest. Use of the timber resource in western Montana increased 500 percent between 1938 and 1959, and the cut on the National Forests increased 3,000 percent during the same period.

STAGE, ALBERT R. Specific gravity and tree weight of single-tree samples of grand fir. Research Paper INT-4, 11 pp., illus.

Prediction equations for specific gravity of 20-year periodic increment on the tree bole, average specific gravity of the tree bole, and the dry weight of the tree bole are derived from a sample of 108 grand fir trees in northern Idaho. The independent variables are: d.b.h., tree height, crown class, and specific gravity of increment core samples at breast height. Functional forms of the equations are based on analyses of variables affecting specific gravity at different heights in the tree.

STAGE, ALBERT R. A mathematical approach to polymorphic site index curves for grand fir. Forest Sci. 9: 167-180, illus.

The usual concept of estimating site index from height at an index age is modified for this tolerant species to compensate for an interval of suppression during establishment. Site index is then defined by the annual height increment on a tree 55 feet tall.

TEW, R. K., (S. A. TAYLOR, and G. L. ASHCROFT). Influence of soil temperature on transpiration under various environmental conditions. Agron. Jour. 55: 558-560, illus. (No reprints)

In growth chambers, variations in air temperature and relative humidity had little influence on transpiration when the soil temperature was low. Low soil temperature was a major factor in controlling transpiration rates.

WAGAR, J. ALAN. Campgrounds for many tastes. Research Paper INT-6, 10+ pp., illus.

Describes kinds of camping most popular with today's vacationers, and discusses the range of campgrounds required to meet these needs.

WELLNER, CHARLES A. The conditions under which site preparation is required and the methods now available. West. Reforestation Coordinating Com., West. For. and Conserv. Assoc. Proc., Seattle, Wash., 1962, pp. 7-11.

Defines site preparation, gives silvicultural purposes of site preparation, presents methods of site preparation, describes where site preparation is needed in the Intermountain and east Cascades forests, and suggests leads to solutions of problems in site preparation.

WILSON, ALVIN K. Commercial pole production in the northern Rocky Mountain area in 1962. Research Note INT-9, 6 pp., illus.

The latest survey of commercial pole production in Idaho, Montana, and northeastern Washington showed that nearly 310,000 poles were produced in 1962. This figure is 29 percent below the output for 1960 (the latest year for which comparable data are available).

ADDENDUM

HUTCHINGS, SELAR S., and (CHARLES P. PASE). Measurement of plant cover--basal, crown, leaf area. IN: Range Research Methods, pp. 22-30; U.S. Dept. Agr. Misc. Pub. 940, 172 pp.

Reviews and evaluates sampling methods and techniques for measuring plant area, including ocular estimates, quadrat charting, variable plots, line interception, point sampling, loop frequency, and point sampling for leaf area. Discusses needs for further research.

JULANDER, ODELL, R. B. FERGUSON, and (J. E. DEALY). Measure of animal range use by signs. IN: Range Research Methods, pp. 102-108; U.S. Dept. Agr. Misc. Pub. 940, 172 pp.

Appraisal of range use by each important species of animal is important in management of both range and wildlife habitat. Discusses use of four types of signs of animal use (pellet-group or fecal-count method; counts of rodent mounds or burrows; spot-count sampling; track counts) and attempts to evaluate them.

KLEMMEDSON, JAMES O., and ROBERT B. MURRAY. Use and measurement of site factors and soil properties in evaluation of range site potential. IN: Range Research Methods, pp. 68-77; U.S. Dept. Agr. Misc. Pub. 940, 172 pp.

Discusses site evaluation in terms of growth potential; considers which site factors and soil properties are likely to be most useful in evaluating range site potential and how they can be measured. Notes opportunity and advantages of using concepts and techniques of site evaluation already developed by foresters.

SHEPHERD, W. O., et al. Committee report on range site measurement and evaluation. IN: Range Research Methods, pp. 89-92; U.S. Dept. Agr. Misc. Pub. 940, 172 pp.

Shows importance of ability to estimate productive potentials of wild lands as part of efficient management of range and wildlife habitat. Discusses and evaluates techniques of site measurement now being used, and indicates generally the advantages and difficulties inherent in each.

Headquarters for the Intermountain Forest and Range Experiment Station are in Ogden, Utah. Project headquarters are also at:

Boise, Idaho
Bozeman, Montana (in cooperation with Montana State College)
Logan, Utah (in cooperation with Utah State University)
Missoula, Montana (in cooperation with Montana State University)
Moscow, Idaho (in cooperation with the University of Idaho)
Provo, Utah (in cooperation with Brigham Young University)